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METHODOLOGY FOR INVENTORYING HYDROCARBONS

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16. ABSTRACT

A methodology for estimating emissions of hydrocarbons to the atmosphere is described, with emphasis on emissions from stationary point and area sources. The methodology is an elaboration of the National Emissions Data System (NEDS), and is based upon, but not limited to, an inventory of hydrocarbon emissions within the Boston, MA Air Quality Control Region; emissions from motor vehicles are not considered, since they are subject to a different methodology. Sources of data, and procedures to obtain data are described. Data sources include trade associations, census figures, and wholesale suppliers. Examples are given of work sheets for compiling data, and of questionaires with instructions for completion that can be sent to various types of establishements that are potential emission sources. Application of the methodology to the St. Louis Air Quality Control Region for development of a hydrocarbon emission inventory for the Regional Air Pollution Study is outlined.

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METHODOLOGY FOR INVENTORYING HYDROCARBONS

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CHAPTER I

INTRODUCTION

This document describes the methods for obtaining stationary source hydrocarbon emission inventory information, cataloguing the information consistent with the National Emission Data System (NEDS), and presenting the information for the evaluation of control strategies. The acquisition of statistical data and the procedure for surveying hydrocarbon stationary sources are described step-by-step. Both the manual approach and the use of computer data handling system are discussed for the analysis of data. Methodology development and application to the EPA Regional Air Pollution Study (RAPS) is also presented.

The definition of hydrocarbon emissions concerned in this report should be clarified. Hydrocarbons are normally thought of as compounds whose molecules consist of atoms of hydrogen and carbon only. Organic compounds include all compounds of carbon except the oxides of carbon, the carbides and the carbonates. Therefore, hydrocarbons are organic compounds. However, all organic compounds, including those which contain additional elements such as nitrogen, oxygen and chlorine, are also defined here as hydrocarbons. Throughout the report, the term hydrocarbon emissions will be synonymous with gaseous and the volatile portion of particulate organic compounds entering the atmosphere.

This report contains five additional chapters. Chapter II reviews the programs concerning the reduction of hydrocarbon emissions. Chapter III describes the methods for collecting information of the study area. Chapter IV delineates the procedure for selecting and surveying the

hydrocarbon stationary sources. Chapter V discusses both the manual and computer assisted methods for compiling and presenting the data. And Chapter VI specifically addresses the utilization of this methodology to the Regional Air Pollution Study Program.

CHAPTER II

REVIEW OF HYDROCARBON PROGRAMS

Since the signing of the Clean Air Act and its amendments of 1970, many programs have been and are being conducted in the area of pollution related to hydrocarbon emissions. A review of the programs dealing with air quality standards, existing and evolving regulations, and the present emissions inventory systems, will lead to an adequate definition of the type of inventory information needed and the methods for collecting this information.

AIR QUALITY STANDARDS

EPA has promulgated two air quality control standards directly or indirectly concerned with hydrocarbons. The photochemical oxidant (or ozone) standard states that the hourly average concentration shall not exceed 0.08 ppm and the non-methane hydrocarbon standard states that the 6 to 9 a.m. average should not exceed 0.24 ppm (measured as "carbon").[1] The non-methane hydrocarbon standard was designed solely to meet the oxidant standard. The document on Air Quality Criteria for Hydrocarbons (AP-64)[2] clearly concludes that "our present state of knowledge does not demonstrate any direct health effects of the gaseous hydrocarbon in the ambient air on populations, although many of the effects attributed to photochemical smog are indirectly related to ambient levels of these hydrocarbons."

Research programs have developed methods for assessing the reactivity of various organic compounds present in auto exhaust and recently in

the solvent and surface coating industries. The reactivities of the compounds vary and classifications have been made according to classes of compounds[3] or for specific compounds as in Table 1. However, "without additional information on the composition of the total hydrocarbon mixture and variability, it is difficult to appraise the relationships in the atmosphere between total hydrocarbon or non-methane hydrocarbon concentrations and photochemical effects."[2] Methane, a photochemically inactive hydrocarbon usually comprises more than half of total atmospheric hydrocarbon. An attempt to correlate photochemical products with non-methane hydrocarbons/total hydrocarbons has been made for several cities.[4] This has resulted in the development of the Appendix J curve, Figure 1, of the Federal Register (August,1971), which is used in the implementation plans to determine the percent reduction required in total hydrocarbon emissions in order to achieve the photochemical oxidant standard. One should note this curve was formed using the upper limit oxidant-nonmethane hydrocarbon points of various mixtures in certain cities over a certain period. It does not reflect the actual relationship of atmospheric hydrocarbons to photochemical air pollution levels over any study area. The application is supposed to assure that more than an adequate reduction is achieved.

STATUS OF NEDS FOR INVENTORYING HYDROCARBONS

Total hydrocarbons is one of the five criteria pollutants catalogued according to point and area source categories. Point and area sources definitions, along with the procedure for coding the computer input forms, are found in the "Guide for Compiling a Comprehensive Emissions Inventory" - APTD 1135.[5] It should be added that a source could be included as a point source if it can be controlled individually by a specific regulation. For example, the hydrocarbon regulation in Los Angeles, Rule 66, specifies "a person shall not discharge into the atmosphere more than 40 pounds of organic materials in any one day (~ 5 tons per year) from any article, machine, equipment ..."[6] It

Table 1. COMPOSITE REACTIVITY INDEX VALUES FOR SELECTED HYDROCARBONS[3]

Compound	Composite Reactivity Inc. (0 to 10 scale)
2-Butene, 2, 3-dimethyl	10
2-Pentene, 2, 3-dimethyl	9
2-Butene, trans-	8
2-Butene, cis-	8
1-Butene, 2-methyl-	8
1-Butene, 3-methyl-	8
2-Butene, 2-methyl-	8
2-Hexene, cis-	8
2-Hexene, trans-	8
3-Hexene, cis-	8
3-Hexene, trans-	8
2-Pentene	8
2-Pentene, cis-	8
2-Pentene, trans-	8
2-Pentene, 4-methyl-	8
1-Butene	7
1-Hexene	7
Formaldehyde	7
Isobutylene	7
1-Pentene	7
1-Pentene, 2-methyl-	7
1-Pentene, 4-methyl-	7
Propylene	7
Propylene Oxide	7
Styrene	7
Vinyl acetate, monomer	7
Vinyl chloride, monomer	7
O-Xylene	7
m-Xylene	7
p-Xylene	7
Benzene, 1, 2, 4-trimethyl-	6
Benzene, 1, 3, 5-trimethyl-	6
1,3-Butadiene	6
Butane, 2-methyl-	6
Cumene	6
Cyclopentane	6
Isobutyl methyl ketone	6
Propadiene	6
Toluene	6
Toluene, diisocyanate	6
Toluene, m-ethyl-	6

Table 1 (continued). COMPOSITE REACTIVITY INDEX VALUES FOR SELECTED HYDROCARBONS[3]

Compound	Composite Reactivity Inc. (0 to 10 scale)
Toluene, p-ethyl-	6
Trichloroethylene	6
Ethylene	5
Ethyl benzene	4
Cyclohexane	3
Cyclohexanone	3
Cyclopentane	3
Cyclomethyl	3
Ethyl methyl ketone	3
Hexanol, 2-ethyl	3
Isopropyl alcohol	3
Methyl alcohol	3
n-Butyl alcohol	3
Acetone	2
Butyl acetates, mixed	2
Ethyl acetate	2
Ethyl alcchol	2
Benzene	1
Butane, 2, 2-dimethyl	1
Butane, 2, 3-dimethyl	1
Hexane	1
Hexane, 2-methyl-	1
Hexane, 3-methyl-	1
Pentane, 2, 3-dimethyl-	1
Pentane, 2,4-dimethyl-	1
Pentane, 2,-methyl-	1
Pentane, 3,-methyl-	1
Pentane, 2, 2, 4-trimethyl-	1
Acetylene	0
Butane	0
Cellulose acetate	0
Diethylene glycol	0
Ethane	0
Ethylene dichloride	0
Isobutane	0
Isopentane	0
Methane	0
Methane, trichlorofluoro	0
Methyl chloride	0
Methylene chloride	0
Peptane	0
Propane	0
Perchloroethylene	0

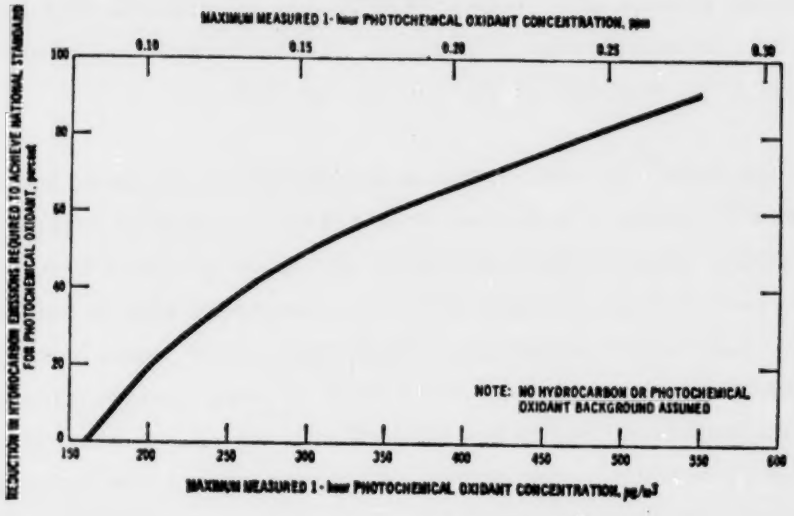


Figure 1. Required hydrocarbon emission control as a function of photochemical oxidant concentration. (Reference: Air Quality Criteria for Nitrogen Oxides, AP-84, Environmental Protection Agency, Washington, D.C., January 1971)

may be reasonable to choose 5 tons/year as a cut-off between point and area sources. The decision is an arbitrary one which also depends on the ease and cost of control and the extent of the photochemical problem.

Table 2 contains a summary of the 1970 nationwide hydrocarbon emissions, by source category.[7] Transportation was the largest hydrocarbon source, emitting 13.2 million tons (48.4 percent of the total) in 1970. The other major sources are, evaporative losses of gasoline and solvents, and industrial process losses. Combined, these sources contributed 9.6 million tons (35.5 percent of the total), in 1970.

Another estimate[3] of total hydrocarbon emissions is shown in Table 3. This summary presents emissions from stationary source categories which are generally higher than comparable estimates in Table 2 due to variations in methodology and data sources. The table also provides estimates of "high reactivity" emissions. "High reactivity" emissions are defined on the basis of photochemical reactivity or smog contribution as determined by simulative laboratory studies and represents that portion of emissions from the various source categories with a composite reactivity index of six or greater (see Table 1). High reactivity does not necessarily correlate with biological response.

Unlike the carbon monoxide and sulfur dioxide, which are specific compounds, the total hydrocarbon emissions consist of numerous types of organic compounds of varying toxicity and photochemical reactivity. These organic compounds may be emitted as a single compound or in combinations with certain others. The types and combinations of these compounds clearly depend on the process and item/product being manufactured or serviced. For some process categories, such as dry cleaning and degreasing, where operations are similar and standardized, the type of pollutant (as a compound) in many cases can be presently specified in the NEDS system via the Standard Classification Code (SCC). For some other categories such as chemical manufacturing and surface coating, the pollutant type information is not specified because the

Table 2. NATIONWIDE ESTIMATES OF HYDROCARBON EMISSIONS, 1970[7]

Source category (P - Point sources, A - Area sources)	Emissions, 10^6 tons/year	Percent of total
Transportation (A)	13.2	48.4
Motor vehicles	12.0	44.0
Gasoline	11.9	43.6
Diesel	0.1	0.4
Aircraft	0.4	1.5
Railroads	0.2	0.7
Vessels	0.6	2.2
Nonhighway use of motor fuels (A)	2.0	7.3
Fuel combustion in stationary sources (P, A)	0.3	1.1
Coal	0.2	0.7
Fuel oil	0.1	0.4
Natural gas	0.0	—
Wood, LPG and kerosene	0.0	—
Industrial process losses (P, A)	5.5	20.1
Solid waste disposal (P, A)	1.5	5.5
Agricultural burning (A)	0.3	1.1
Miscellaneous (P, A)	4.5	16.5
Forest fires[a]	0.2	0.7
Structural fires	0.1	0.4
Coal refuse burning	0.1	0.4
Gasoline and solvent evaporation	4.1	15.0
Total	27.3	

[a]Includes prescribed burning.

Table 3. "BEST ESTIMATE" REACTIVITY RANKING OF MAJOR EMISSION SOURCES[3]

Source category	Total hydrocarbon emissions (10^6 tons/year)	"High reactivity" emissions (10^6 tons/year)
Solvent Evaporation	7.1	1.9
Solid Waste Combustion (urban, domestic, commercial, and industrial)	4.5	1.4
Agricultural Waste Combustion	4.2	1.1
Petroleum Products Storage and Marketing	2.3	1.0
Petroleum Production and Refining	1.9	0.2
Chemical Process Industry	1.4	negligible
Other Industrial Processes	~ 1.0	negligible
Fuel Combustion	0.4	negligible
Coal Refuse Burning	0.2	not estimated
Forest Wildfires	2.4 - 3.0	not estimated
Totals	25.4 - 26.0	5.6

SCC process codes have not been developed, or the pollutant is just categorized as solvent, paint solvent, lacquer solvent, etc. Solvents in mixtures vary but general classes could be outlined and SCC's defined. Still, for other categories such as area sources, where no SCC listing exists, only the material being stored, consumed or combusted is known. Emission factors are applied to these area source categories to calculate the total hydrocarbon emissions. If it is ever needed, the types, amount and variability from each area source category could be determined. For example, the marketing of gasoline certainly emits most of the compounds found in gasoline and the more volatile in larger quantities. Also, combustion of certain fuels usually produce various types of organic compounds within a limited concentration range.

REGULATIONS FOR THE CONTROL OF HYDROCARBON

A critical review of the existing and proposed regulations for the control of hydrocarbon emissions from stationary sources has recently appeared in the Journal of Air Pollution Control.[8] In summary, the various state and local agencies having a photochemical oxidant problem, have adopted some variation of the Los Angeles Rule 66.

Recently the National Paint and Coatings Association (NPC) has recommended modifications of Rule 66 for the control of Organic Solvents. These are proposed for use as new Federal Guidelines. These regulations or some slight modifications of them might eventually be adopted by the states or local agencies considering control of stationary hydrocarbon sources.[9]

It is evident that some of these regulations at times apply selective control to the particular categories or pollutant types. For example, below is a part of the regulation on organic solvent use:[9]

A person shall not discharge into the atmosphere more than 40 pounds of organic materials in any one day, nor more than 8 pounds in any one hour, from any article, machine, equipment or other contrivance used under conditions other than described in section (a), (drying) for employing, or applying, any photochemically reactive solvent, as defined in section (k), or material containing such photochemically reactive solvent, unless said discharge has been reduced by at least 85 percent.

For the purposes of this rule, organic solvents include diluents and thinners and are defined as organic materials which are liquids of standard conditions and which are used as dissolvers, viscosity reducers or cleaning agents, except that such materials which exhibit a boiling point higher than 220°F at 0.5 millimeter mercury absolute pressure or having an equivalent vapor pressure shall not be considered to be solvents unless exposed to temperatures exceeding 200°F.

For the purposes of this rule, a photochemically reactive solvent is any solvent with an aggregate of more than 20 percent of its total volume composed of the chemical compounds classified below or which exceeds any of the following individual percentage composition limitations, referred to the total volume of solvent:

1. A combination of hydrocarbons, alcohols, aldehydes, esters, ethers or ketones having an olefinic type of unsaturation: 5 percent;

2. A combination of aromatic compounds with eight or more carbon atoms to the molecule except ethylbenzene: 8 percent;

3. A combination of ethylbenzene, ketones having branched hydrocarbon structures, trichloroethylene or toluene: 20 percent.

As specific and well defined as these regulations may be, the complex problem of evaluating the number and type of hydrocarbons emissions from a plant or class of industries still exists.

Under different circumstances, EPA has used different reactivity criteria in developing control strategies. The control regulations for automotive emissions require the control of all hydrocarbons. The regulations for gasoline marketing and distribution control all emissions, except that in some areas C_1 to C_3 paraffins, acetylene and benzene are exempted. For

solvent usage, where control technology is not available, use of less reactive compounds has been permitted according to regulations similar to those given above.

CONCLUSION

From these earlier discussions, it is apparent that regulations have been and are being developed with the concept of photochemical reactivity. Up to now EPA has relied on the Appendix J relationship in the development of the implementation plans because of the unknown makeup and reactivity of the many organic components involved in the complicated photochemical reactions and forming oxidants. Since research is actively providing more information on these relationships, it appears that an accurate catalogue for inventorying hydrocarbons by type should be developed. The cataloguing of emissions should be consistent with the existing and eventual control strategies for meeting the oxidant standard. Toxicity effects should also be considered.

CHAPTER III

DESCRIPTION OF REGION

To properly study a hydrocarbon emission problem for an area in question, it is necessary to have a complete description of the region. After the study area has been chosen, all necessary maps of the area should be obtained. City and county maps can usually be supplied by the State Department of Commerce and Development. Traffic count maps should be obtained from local and state highway departments and from metropolitan planning agencies. USGS maps should be used to identify the location (UTM's) of point sources.

It is very helpful prior to mailing a questionnaire, to have a general understanding of the types of major industries that exist in the study area. A list of manufacturing employees and/or number of establishments versus SIC (Standard Industrial Classification) can quickly reveal the major type of manufacturing industries in the area. This information can be obtained from the latest published Bureau of Census Data or the State Industrial Director. Table 4, constructed for the Boston AQCR, indicated SIC 38, 36, 31, 30 and 27 to be major industries. Petroleum bulk storage and distribution and dry cleaning establishments would also be included in any inventory because they are know emitters of hydrocarbons.

Statistical information that will be needed for the apportionment of hydrocarbon emissions to cities, towns, and counties are the following: population, number of establishments, number of manufacturing employees per SIC for cities, towns, counties, Standard Metropolitan Statistical

Table 4. MANUFACTURING EMPLOYEES IN REGION BY SIC CATEGORY, 1973

SIC category	Manufacturing employees[a]	~% of[b] U.S. Total
20 Food	21,900	1.6
22 Textile products	5,400	1.1
23 Apparel	17,300	
24 Lumber	2,400	0.6
25 Furniture	3,000	
26 Paper	11,600	(1.7)
27 Printing	25,000	2.1
28 Chemicals	9,000	0.9
29 Petroleum	1,000	(0.5)
30 Rubber	12,100	(2.3)
31 Leather	13,200	(3.9)
32 Stone, clay, etc.	3,000	(0.5)
33 Primary metals	3,400	0.3
34 Fabricated metal roducts	17,500	1.2
35 Machinery, non-electrical	34,000	1.7
36 Electrical machinery	52,000	2.7
37 Transportation equipment	16,600	0.8
38 Instruments	25,600	(6.2)
39 Miscellaneous manufacturing	6,900	(1.5)
Other	5,600	
	286,000	

[a]Primarily from September 1973 Massachusetts "Employment Newsletter"

[b]From ratio of 1973 Regional to 1970 National Bureau of Census Data, values in ( ) from 1967 Census Data

Areas (SMSA) and state. This information is usually available in Bureau of Census publications. Information about the labor force, population characteristics and general information for cities and towns can possibly be obtained from the local Development Council or the State Department of Labor. Often it is compiled in monographs for the respective city or town by state agencies.

Data concerning the amount of fuel consumed, transferred, stored, and produced for each state can be obtained from the "Mineral Industry Surveys" prepared by the U.S. Department of the Interior, Bureau of Mines.

Information about airport operations that are in the study area can be obtained from the Department of Transportation, Federal Aviation Administration.

Other ways of obtaining statistical information, which may not have been previously mentioned, can be found by referring to the reference sections in the "Guide for Compiling a Comprehensive Emission Inventory" (APTD 1135).

Metropolitan Boston Intrastate Air Quality Control Region, Figure 2, was a typical area chosen for a hydrocarbon emission study.[10] For this region the city replaced the county concept followed in NEDS.

Figure 2. Metropolitan Boston Intrastate Air Quality Control Region

CHAPTER IV

HYDROCARBON STATIONARY SOURCE IDENTIFICATION

A primary purpose of a hydrocarbon inventory is to identify stationary point sources. This is best undertaken by means of a stationary source questionnaire. One byproduct of the questionnaire mailing is the gathering of information about small companies that do not emit hydrocarbons in sufficient quantity to qualify as point sources. Although these sources are small, they are numerous and may represent a substantial portion of the total hydrocarbons being emitted. The emissions from these area sources should be included in the NEDS area source file.

Hydrocarbon stationary sources can be broken down into the following categories: fuel combustion, solid waste, process and evaporation sources. Fuel combustion includes the burning of coal, oil, gas, and wood for residential, commercial, institutional, and industrial use. Solid waste stationary sources are on-site incineration, and open burning. Point and area source information for both fuel combustion and solid waste can be obtained from the existing NEDS file. It is felt that there is no real need to re-examine these point and area sources because of past emphases placed on them as emitters of criteria pollutants. The rest of this chapter discusses process and evaporative stationary sources.

PROCESS AND EVAPORATIVE SOURCES

Frequently hydrocarbon emissions from process and evaporative sources have not been carefully cataloged in the past. Therefore, it is

necessary to re-examine the industries in the study area. A questionnaire designed specifically for particular classes of industries is effective in gathering the necessary process, emission and emission control information.

The questionnaire should be designed for three types of establishments: the manufacturing industries, the dry cleaners and the bulk petroleum products distributors.

Manufacturing Industries - (Questionnaire Design)

The operations that frequently emit hydrocarbons from the manufacturing industries are listed below.

1. Degreasing
2. Surface coating
   a. Fabric or rubberized
   b. Protective or decorative
   c. Printing
   d. Miscellaneous surface coating
3. Other manufacturing operations
   a. Process losses
   b. Bulk storage

The questionnaire for these manufacturing industries is shown in Appendix A, Table A-1. On the first page, general information is requested. Plant name and mailing address, plant address, person to contact, number of manufacturing employees, etc., are required for identification, scale up and completion of NEDS. To assist the respondent a guide (Page 1, Item G) is provided indicating the pages that should be completed for the operations performed at the plant. If the plant does not emit hydrocarbons, the respondent signs the form and returns it so he will not be recontacted.

Degreasing - In many industries, the fabricated product must be degreased before the application of surface finishes. The major solvents used in degreasing operations, Stoddard, 1,1,1-trichloroethane, perchloroethylene, methylene chloride and trichloroethylene are listed on the questionnaire. Space, of course, is also provided for other solvents. The respondent is also asked to identify the amount of each solvent purchased and returned for reprocessing. In order to assist in the determination of how much solvent is being sold in the area, the name of the solvent supplier is requested. The major solvent suppliers, if willing to disclose what may be considered as proprietary information, could provide information concerning total solvent usage within the area and help in the identification of major sources.

Surface Coating - The section concerning surface coating, should be handled carefully because solvents are added to the purchased coating. A distinction must be made between quantity of coating purchased and its solvent content, and the quantity of solvent added to the coating for dilution. The amount of solvent used for cleaning purposes is also requested. Since several solvents are often used, the type and percentage of the major solvents in the coating should be indicated on the questionnaire.

Manufacturing - The last operation in this major category is manufacturing. This part is a catch all, which includes such industries as asphalt roofing, plywood/particle board products and chemical manufacturing. Space is provided to describe the process or operation, to indicate the material being processed, to indicate the throughput at the source and to indicate the percentage and types of solvents being used and lost to the atmosphere.

In order to obtain the information required to fill out a NEDS form for a point source, one last page of information is needed. This part of the questionnaire concerns itself with control equipment and stack

information. Every piece of equipment that has been mentioned in any previous page of the questionnaire should be given a unique source identification number. This number is used to match a piece of control equipment or a stack to the proper piece of operating equipment. Information that is needed includes the following:

- Process or operation having a stack and/or control equipment
- Control equipment specification
- Efficiency of the control equipment and its date of installation
- Stack information: height, diameter, gas temperature and velocity

The date of installation can be used to double check the reported efficiency of that equipment. If a piece of equipment is 50 years old and it is reported at 99 percent efficiency, a reasonable doubt exists as to the reported values.

Dry Cleaning - (Questionnaire Design)

Dry cleaning is the second category for which a questionnaire should be developed. It can be a separate questionnaire or incorporated into the manufacturing industries questionnaire as shown in Table A-1. Dry cleaners are requested to complete page 2 instead of pages -3- to -8- of the manufacturing industries questionnaire. General, stack, control and bulk storage information remains the same. The dry cleaning operation uses basically two types of solvents; perchloroethylene and some form of Stoddard solvent. The users of Stoddard solvent will, in almost all cases, use a type of process called a transfer machine. It is called a transfer process because after the clothes are washed they are transferred to a separate dryer. The physical process of moving the wet clothes necessitates that there will be a large evaporative loss. The second type of process used in dry cleaning is called a dry-to-dry

machine and is also used by coin operated cleaning establishments. This process does not involve a transfer of clothes. The drying cycle is performed in the same machine as the washing cycle. The question of what type of process is being used should be included in order to check the usage figures of solvents. For the same amount of clothes cleaned and for the same type of solvent being used, the transfer process should use more solvent than the dry-to-dry process. As in the manufacturing questionnaire, the names of the suppliers of solvents are requested to assist in the determination of solvent usage in the area.

Bulk Storage of Petroleum Products (Questionnaire Design)

The last major category is bulk storage of gasoline and other petroleum and petrochemicals. In order to obtain information about storage tanks that a company may have on its premises, an abbreviated form of a bulk storage section is sent to all manufacturing industries (Section VII of Questionnaire). This shortened form asks for information concerning solvent type, capacity of the tank, annual throughput, and fill and control equipment.

The complete form, Table A-2, is sent to all major oil companies, petroleum and petrochemical distributors, utilities, and airports that have large bulk storage tanks. The questionnaire asks for information such as tank dimensions, paint on tank, average vapor space height, type of roof, vapor pressures of liquid, type of fill, etc. All necessary information is asked so that the emissions from the tank can be calculated based upon methods described in the Compilation of Air Pollution Factors, AP-42.[11] Emissions from product transfer are calculated by obtaining the type of fill (splash or submerged) and throughput at the loading racks.

DEVELOPMENT OF MAILING LIST

After a questionnaire has been developed for the specific area in question, a mailing list of potential hydrocarbon emission sources should be compiled. This list of companies can be obtained from many sources. Some examples are:

- State Industrial Directories
- State Department of Corporations and Taxation
- Dun and Bradstreet, Industrial Directory
- Yellow pages of telephone directories
- Thomas Register
- Trade and professional societies
- Existing NEDS and CDS for the state
- State Air Pollution Control Agency
- Local communities to obtain appraisal of industrial activity and listing of solvent storage facilities
- Manufacturers, suppliers and users of solvents and control equipment.

The selection of companies to be contacted is based on their SIC classification, with consideration given to their size and nature of their actual operations through preliminary contact with the firm, local municipalities or suppliers. Information from two previous studies shows significant use of hydrocarbons in the manufacturing industries (SIC 20 to 39), bulk storage and distribution of petroleum products (SIC 5171) and dry cleaning services (SIC 7216).

After the selection has been made of the industrial categories (SIC codes) to be surveyed by questionnaire, it is then necessary to determine if all the companies in the SIC will receive the questionnaires or whether only the most probable users of solvent based upon employee size will receive the questionnaire. Experience from past studies shows that it is helpful to make preliminary telephone calls to representative companies in an SIC. The information obtained can then be used to determine

if all companies in this class would receive a questionnaire or whether for example, only companies with 50 employees or more should receive the questionnaire.

Table 5 presents guidelines that may be useful in the selection of companies based upon a previous Rhode Island study. The emission employee ratio is the ratio of tons of hydrocarbon emitted per employee as found from respondents. This figure can be used to determine the size of companies that should be inventoried. For example, if it is decided that all companies emitting more than 5 tons of hydrocarbon will be considered as point sources and the SIC emission employee ratio is 0.5, then all companies with 10 or more employees should be surveyed. It should be emphasized that this table is based on a small sample of all the U.S. industries and should be used with discretion until more hydrocarbon surveys are conducted.

The last two categories should be completely surveyed. A list of petroleum bulk stations and terminals can be obtained from the following sources:

1. State Air Pollution Control Agency
2. Department of Corporations and Taxation
3. New England Yellow Pages
4. Petroleum Industry Publications

A list of dry cleaning establishments can be obtained from either the Yellow Pages or from the Regional Dry Cleaning Trade Association.

The development of the mailing list involves classification of the companies that have been chosen to be surveyed into a logical order. But, before this is done it is necessary to minimize duplicate mailings. To do this all the mailing information about a company is keypunched on computer cards. This information is then sorted alphabetically by city or town. Visual spot checking will easily eliminate most of the duplicate names from the computer printout. However, even though extreme

Table 5. GUIDELINES TO DETERMINE WHAT COMPANIES WILL BE SURVEYED

SIC		Selection criteria	Emis./emp. ratio (tons/employee)
20	Food	Alcoholic beverages (2085)	-
21	Tobacco	Not surveyed	-
22	Textiles	Coatings (2295), Non-wovens (2297), Dyeing (2231)	0.89
23	Apparel	Not surveyed	-
24	Lumber & wood	Finished product (2435), (2492)	0.07
25	Furniture & fixtures	SIC: (2511), (2514), (2521) (2522), (2542) .	0.08
26	Paper	Bags, box (2643), 2651), (2653), Coated papers (2641)	1.0
27	Printing	Newspaper publishing (2711) Comm. printing (2751), (2754)	0.5 0.20
28	Chemicals	Organic chemical mfg. (2821), (2823), 2861), Chemical coating (2851), Specialty chemicals (2842), Carbon black (2895)	0.32
29	Petroleum	All companies	0.11
30	Rubber, plastic	Footwear (3021), Plastics (3041), (3069)	0.16
31	Leather	Mfg. shoes (3149), Bags (3161), Personal goods (3172), Leather refinishing (3111)	-
32	Stone, clay, etc.	Glass products (3221)	0.03
33	Primary metal	Treating (3398), Tubing (3357)	0.10
34	Fab. metal	Screws (3451-2), Metal stampings (3469), Plating (3471), Tool mfg. (3423), (3429)	0.19
35	Machinery	Industrial machines	0.03
36	Elect. Machinery	Devices (3643), Semicond. (3674)	0.07
37	Transpt. equip.	Boats (3732), Truck bodies (3711), 13, 14, 15)	0.11
38	Instruments	Optical frames (3832) Precision instruments (3825)	0.04
39	Misc. Mfg.	Jewelry (3914-15), Toys (3944), Writing instr. (3951, 53)	0.07
5171	Bulk terminals	All surveyed	-
7216	Dry cleaning	All surveyed	-

caution is undertaken in developing the list, duplication of companies will still exist. This is due to the fact that some companies have more than one name (e.g., parent company, subsidiary, old name). This type of duplication generally will not be discovered until it is time to recontact those companies that did not initially respond.

A logical order in which to list and classify companies is first by SIC, then by city or county and finally alphabetically within the city or county. This order will increase the efficiency of all future work involved in data handling and in recording and analyzing response information.

COMPUTER LABELS AND WORK SHEET

A computer program can be very helpful in the mailing of the questionnaire, and in the production of a work sheet used for logging the returns. The computer program should produce duplicate mailing labels. The first label is attached to the general information page. This is done for identification of returned questionnaires and for name and mailing address correction. The second label is attached to the outside of the envelope. The label is shown below in Figure 3.

```
XXXX                              XXXX
 TRIAL NAME,
 STREET ZZ,
WOONSOCKET          R.I. 02895
```

Figure 3. Label contents

The SIC classification number is printed on the upper left and an assigned identification number on the upper right. The ID number is used to keep records of all correspondence with the company. In the middle of the label appears the company name, address, and zip code.

Figure 4 shows the work sheet listing of the companies in identification number order. It is used to record the dates questionnaires were mailed and returned, the telephone numbers, the telephone contact notes, and comments. The comment space can contain the type of source, process, emissions and number of manufacturing employees required for data analysis. The computer program listing for doing the above tasks is found in Appendix B.

MAILING OF QUESTIONNAIRE

There are certain procedures that should be followed to assure a good questionnaire response. Legal requirements should also be considered; for example, some state regulations may require that prior to the mailing of a questionnaire ample notice be given in local papers. A cover letter such as that shown in Figure 5 should accompany all questionnaires, this letter should state the purpose of the study, make reference to any proposed or applicable regulations, and request cooperation. General procedures and instructions for the previously designed questionnaire such as those shown in Figure 6 should also be provided. These instructions should request completion and return of the questionnaire by a specific date and specify the year for which the data is requested. The instructions also should explain that the questionnaire was designed for a wide variety of operations which involve solvent and organic chemical usage, and that some questions may not apply to a particular facility. A telephone number should be supplied in case a respondent has questions concerning the form.

The mailing of the questionnaire can be performed in two ways. The first method is by registered mail. Using this method the agency is assured that the questionnaire is received by the company. The percent response will probably be higher than if than if the letter was sent by conventional mail. However, there is still no guarantee that the company will return the form. It is felt that the slight increase in response does not justify the added expense of sending every company a registered letter.

		TEL NO	DATE Q IN	TEL CONT	TEL CONT	TEL CONT	COMMENTS
XXXX TRIAL NAME, STREET ZZ, WOONSOCKET	XXXX R.I. 02895						
XXXX TRIAL NAME, STREET ZZ, WOONSOCKET	XXXX R.I. 02895						

Figure 4. Work sheet contents

The Commonwealth of Massachusetts
Department of Public Health

600 Washington Street, Boston 02111

Division of
Environmental Health
Room 320

Dear Sirs:

The enclosed questionnaire is being sent under the auspices of the Massachusetts Department of Public Health, Division of Environmental Health, Bureau of Air Quality Control, in cooperation with the United States Environmental Protection Agency. The information being sought concerns the usage of organic (solvent containing) materials, and will be used to determine the effect of such materials on the air quality levels in the southern portion of the Commonwealth.

We would appreciate your assistance and cooperation in answering those questions that are applicable to your operations. Even if your facility does not utilize organic materials it is required that you return the questionnaire so that you will not be bothered by a follow-up phone call.

Many thanks for your cooperation in this effort.

Very truly yours,

Gilbert T. Joly

Gilbert T. Joly
Director
Bureau of Air Quality Control

GTJ/TP/mb

Figure 5. Cover letter

HYDROCARBON (SOLVENT) EMISSION STUDY
FOR STUDY AREA

The Division of Air Pollution Control, Department of Public Health requests your cooperation in providing the information asked for on the attached questionnaire concerning potential hydrocarbon emissions resulting from the operation of your facility. Hydrocarbons are gaseous organic compounds.

BEFORE FILLING OUT THE QUESTIONNAIRE
PLEASE READ THE FOLLOWING INSTRUCTIONS:

- Everyone receiving this form should complete Section I (General Information) and all other sections pertaining to his firm and return the questionnaire in the stamped, addressed envelope.
- Please return the questionnaire on or before May 17, 1974. Your cooperation and expeditious completion of the inventory forms will be appreciated.
- Indicate any change in name and/or address in Section I.
- The information submitted should pertain to the calendar year of 1973.
- The questionnaire was designed for a wide variety of operations which involve extensive solvent usage. Accordingly, many questions may not apply to your facilities. Please complete only those sections that are applicable to your operations.
- If there is more than one plant location, please request additional copies or photocopy it for each facility.
- If tne space provided is not adequate, feel free to either copy the form, use a separate sheet or request an additional copy.

Your cooperation in filling out this form is greatly appreciated. If you require additional forms or further information, please contact Mr. X or Mr. Y, Tel. No.: XXX-XXXX

*Division of Air Pollution Control
Street Address
City, State, Zip Code

Figure 6. General instructions for completing questionnaire

The second method is by conventional first class mail. This method previously used in past studies has proved to be effective if, on the outside envelope, the following expression is clearly printed, "ATTENTION: PLANT MANAGER." This expression directs the envelope to the proper supervisory personnel and reduces the chances of the envelope being discarded. Included with the questionnaire should be a self-addressed stamped envelope. The public is more likely to return the questionnaire if the postage has already been prepaid.

One factor that should be considered before the mailing is whether or not to stagger the mailing over a time period. If a large number of questionnaires (1,000 or greater) are to be mailed, a staggering of the mailing should be considered. This allows for a more even flow of returns and eases the task of recording information contained in the returned questionnaires. If the mailing is spread out over extended periods of time the return date of the questionnaire should also be staggered accordingly. Companies should be given a reasonable amount of time to respond. For most companies, approximately 3 to 4 weeks is sufficient.

Generally, responses will start coming in within a few days after mailing. Many of the early returns will be from companies that do not use hydrocarbons in their facility. Also, some of the envelopes will be returned from the Post Office because either the establishment is out of business or because the company is no longer at that address. New addresses for companies that have moved can be obtained by either looking up their addresses in the telephone book or by contacting the Department of Corporations and Taxations.

LOGGING OF RETURNS AND FOLLOW UP

Emission calculation can be performed on the questionnaires as soon as they are returned. One of five classifications should be designated on the return:

- P - Hydrocarbon point source
- A - Hydrocarbon area source
- N - No hydrocarbon emission, non-source
- OOB - Out of business
- R - Recontact for reclassification

Emission from many sources within a company should be broken down into individual point sources. The smallest point source that should be considered within a company is one having at least 1 ton of emissions.

As the responses come in, changes should be made to correct any mistakes made in the company's name, address or SIC classifications. Information required for data compilation is recorded on the work sheets described in Chapter V.

RECONTACTING

Approximately 3 to 4 weeks after the questionnaires were initially mailed, recontacting should begin. This can be accomplished by either of two methods, telephone or letter. The advantages to recontacting by telephone are direct verbal communication, and lower costs when the calls are local. Direct communication quickly identifies any problem areas. Process information can also be obtained over the telephone. In an average 8-hour work day it is possible for one person to recontact approximately 30 to 40 companies. A good approach is to select the larger companies in SIC categories emitting significant amount of hydrocarbons. Certainly all the bulk storage establishments should be recontacted.

CHAPTER V

DATA COMPILATION

There are two approaches for compiling the data into summary tables that can be used to analyze hydrocarbon source emissions and study the effects of regulations. One approach is to process the information manually. The other is to use a computer data handling system. The selection of one approach over another depends on several factors. The computer approach is advantageous when the data base is large, a variety of tabular summaries have to be produced and the tasks are iterative. The computer approach also forces organization. Since the tasks are done systematically, this leads to accuracy and efficiency.

It has been noted that the methodology for inventorying hydrocarbons requires information on numerous organic compounds from a variety of processes. Because of this complexity and the eventual need for many studies of this type to be done for different regions (states, AQCR) in the future, it is recommended that a computer data handling system be developed similar to that described in the paragraphs entitled "Computer Data Handling System," in this chapter. The manual approach, which has been used as the basis for the development of the computer data handling system, is described thoroughly in the section entitled "Manual Approach." It may be followed for small data bases or when more flexibility or variation from the computer system approach is desired.

MANUAL APPROACH

The data in the questionnaires and the information gathered on the return log sheet are used to do a survey coverage analysis and to prepare a point and area source listing work sheets by major emission categories. The extent of survey coverage and hydrocarbon emission information by by category is then used to estimate total stationary source hydrocarbon emissions. The information on point source work sheets is coded onto NEDS point source forms. Area sources estimates for each major manufacturing and evaporative category are calculated and then summed for entry by county into the evaporation field of the NEDS area source form.

Other hydrocarbon area source emissions for each county are calculated either by the NEDS area source computer program or manually as specified by the "Guide for Compiling a Comprehensive Emissions Inventory,"[5] APTD-1135 and "Compilation of Air Pollutant Emission Factors," AP-42.[11] Point source hydrocarbon emissions from fuel combustion and solid waste are also obtained from the NEDS point source printout.

Total hydrocarbon emissions can be summarized by source category for the region or each county as shown in Table 6. The Pi chart in Figure 7 is an excellent way to illustrate the percent contribution of each source category. A table similar to Table 7 is used to list the point sources. Finally, an analysis of each source category can detail the types of processes, types of hydrocarbon species emitted, and types of equipment presently in use or available for control.

Survey Coverage Analysis

The extent of survey coverage and the resulting emissions is demonstrated in Table 8. The latest census data on the number of companies and manufacturing employees by SIC presents a good accurate picture of what can fully be surveyed. The number of companies surveyed was based

Table 1. SUMMARY OF HYDROCARBON EMISSIONS FOR 1973 IN RHODE ISLAND

Source category	Point source		Area source emissions	Total emissions
	Number[a]	Emissions		
Dry cleaning	29	370	907	1,277
Degreasing	120	2,911	1,830	4,741
Surface coating	103	9,040	5,316	14,356
Fabric/rubber				(2,225)
Protective/decorative				(4,108)
Printing				(1,828)
Miscellaneous				(4,395)
Trade Paints				(1,800)
Manufacturing	9	721	74	795
Bulk petroleum products Storage	20	7,945	~ 0	7,945
Fuel combustion	50	293	958	1,251
Solid waste incineration	5	36	~ 0	36
Gasoline marketing	NA	NA	4,118	4,118
Aircraft	NA	NA	1,211	1,211
Railroads & vessels	NA	NA	137	137
Totals	336	21,316	14,551	35,867

( ) sub-entries

NA Not Applicable

(a) An establishment may be doing operations in more than one source category. Actually 280 establishments are sources.

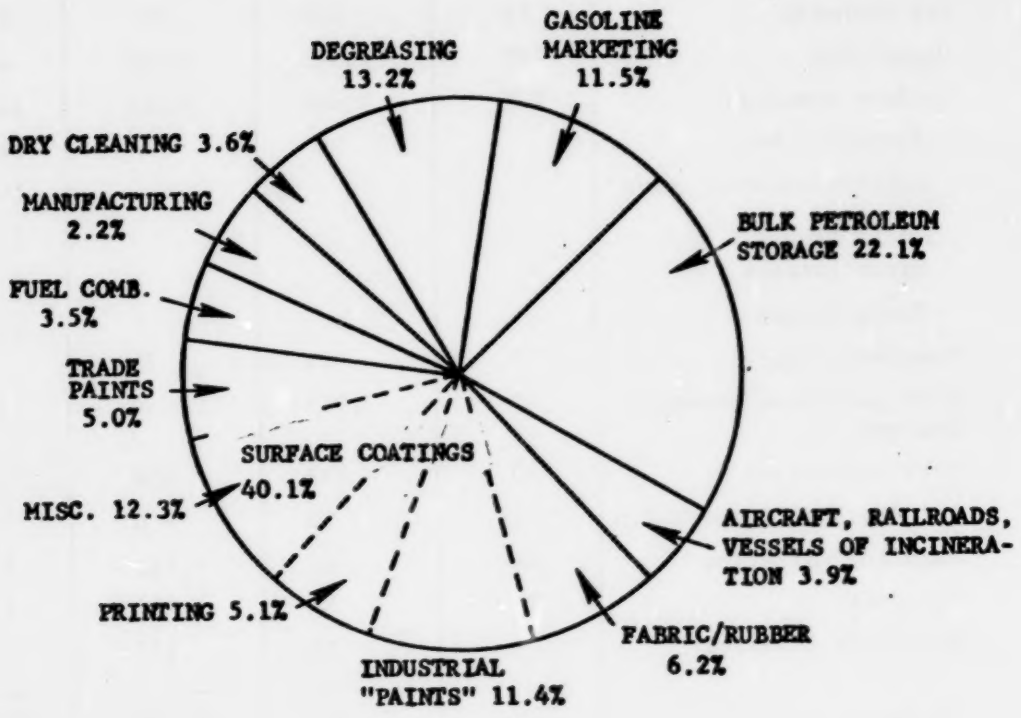


Figure 1. Distribution of total hydrocarbon emissions except from automobile travel (35,900 tons/yr) in Rhode Island

Table 7. HYDROCARBON SOURCES GREATER THAN 5 TONS/YEAR, 1973

For _____

Plant I.D.	Company	Emissions by source category (tons/year)								
					Surface coatings					
		Bulk storage	Dry cleaning	De-greasing	Fabric & rubber coatings	Paints	Inks	Other	Chem. mfg.	Fuel comb. & inc.

Table 8. SURVEY COVERAGE AND RESULTING EMISSIONS

SIC	Category	Region 1967 census or (1972 manuf. directory) data			No. of companies surveyed	Companies responding								Out of business or duplicate	Percent coverage (companies) surveyed	Percent coverage (employees) surveyed	Total estimated HC emis.
						Point sources			Area sources			Mon sources					
		No. of companies	No. of co. > 20 empl.	No. of employees		No. of co.	No. of empl.	HC emis.	No. of co.	No. of empl.	HC emis.	No. of co.	No. of empl.				
22	Textiles 2231, 2295, 2297	(282)	187	3,700	57	19	2,766	3,981	4	400	10	22	1,339	12	100	100	3,991
24	Lumber	(38)	6	500	12	1	45	7	2	28	4	5	95	3	92	34	138
25	Furniture	(43)	7	700	21	0	0	0	10	51	7	10	34	1	100	12	303
26	Paper	(57)	32	2,800	41	5	852	2,237	12	517	16	21	876	1	95	80	2,827
27	Printing	(185)	38	4,400	99	9	1,978	252	63	2,142	19	13	1,192	11	97	100	299
28	Chemicals	(90)	25	3,000	53	7	1,445	732	25	750	37	14	635	5	96	94	843
29	Petroleum	(6)	--	300	2	2	145	16	0	0	0	0	0	0	100	48	16
30	Rubber	(84)	33	9,750	55	13	5,541	1,180	16	409	10	20	1,553	5	98	77	2,015
31	Leather	(18)	12	1,500	6	1	70	27	1	150	1	1	12	3	67	15	354
32	Stone, clay, etc.	(52)	14	2,500	3	1	600	19	0	0	0	2	100	0	100	24	39
33	Primary metals	(114)	40	9,700	78	8	1,444	373	9	365	8	54	1,872	7	100	62	698
34	Fab. metal prods.	(406)	89	8,500	253	33	3,115	1,160	52	1,044	82	124	2,364	25	92	77	2,016
35	Machinery	(272)	57	10,900	155	12	6,183	275	28	1,801	25	93	1,196	16	96	84	433
36	Elect. machinery	(61)	32	8,300	68	16	10,197	1,116	22	3,885	29	14	1,490	16	100	100	1,145
37	Transp. equip.	(28)	15	1,450	15	5	616	110	6	389	12	3	140	1	100	79	263
38	Instruments	(42)	15	4,100	13	2	815	56	4	206	3	7	476	0	100	37	217
39	Misc. Mfg.	(955)	227	24,200	136	45	10,142	1,000	41	3,381	80	27	2,155	18	96	65	2,524
	Subtotals	(2,733)	829	96,300	1,060	179	45,554	12,541	295	15,518	340	430	15,529	124	98	79	18,121
5153	Bulk storage	13 [a]	--	--	20	20	--	7,945	0	--	0	0	--	0	100	--	7,945
7215 & 7216	Dry cleaning	277 [b]	--	--	277	29	--	370	40	--	107	54	--	16	47	--	1,277
	Totals	3,023	829	96,300	1,357	228	45,554	20,856	335	15,518	447	484	15,529	140	86	79	27,343

[a] Source - Rhode Island Department of Public Health, Division of APC

[b] Source - Telephone Yellow Pages

on the selection procedure in Chapter IV, "Development of Mailing List." The responding information is obtained from the work sheets completed as questionnaires were returned. Hydrocarbon emissions are normally calculated by scaling up to 100 percent manufacturing employee coverage of the selected industrial categories (two-, three-, or four-digit SIC).

In certain cases no scale-up should be performed, because the number of responding companies or the number of reported employees exceeds the latest census information. Additional estimates and corrections are made by a careful analysis of each SIC and major category (dry cleaning, degreasing, printing, etc.). Statistical information or that obtained from major solvent suppliers should also be considered in any reestimation of survey information.

Point and Area Source Work Sheets

The point and area source work sheets are shown in Tables 9 and 10. They are completed as an intermediate step prior to summarizing the type and amount of hydrocarbon emissions by major category, city/county, or SIC. They are also useful for developing the NEDS point source structure and coding information. Control equipment type and efficiency, process type, and operating rate information may also be variables for other summaries.

An entry is made for each point source belonging to a major category such as dry cleaning, degreasing, etc. Processing equipment or method, industrial type and pollutant type are described to facilitate SCC selection and decoding. An attempt is made to select the appropriate SCC by hydrocarbon type or mixture, otherwise a catch-all SCC ending in 99 is chosen.

Table 9. POINT SOURCE WORK SHEET

Category_____

NEDS ID.	NAME	CITY/CO	SIC	MFG. EMPL.	STUDY ID.	PT. ID.	PROCESS TYPE	CONTROL EQT.	EFF.	SCC	MATERIAL & OPERATING RATE	POLLUTANT	EMISSIONS (TONS/YR)

Table 10. AREA SOURCE WORK SHEET

Category_____

Study ID	NAME	CITY/CO.	SIC	MFG. EMPL.	POLLUTANT	EMISSIONS (TONS/YR)

Summary of Hydrocarbon Emissions by Major Category, SIC and Pollutant

A table similar to Table 11 is constructed to analyze the hydrocarbon emissions by SIC and major categories. Point and area source emissions are given by SIC for each type of pollutant. The last few columns give the reported survey totals and the calculated nonreported survey totals. The nonreported survey total is estimated using percent survey coverage information and any additional estimates from national or regional figures. Any additional amount is apportioned to SIC's by the extent of the coverage and the reported hydrocarbon emissions within each SIC. A discussion on the method for estimating nonreported emissions for each category follows. Calculation procedures are only detailed in the paragraph entitled "Degreasing."

Degreasing - Trichloroethylene, perchloroethylene, and 1,1,1 trichloroethane are the solvents most commonly used for vapor and cold degreasing. Other solvents include methylene chloride, Stoddard solvent and lesser quantities of others (ketones, alcohols, aromatic compounds, etc.) which could be classified under "other." Companies classified within SIC codes 34 to 39 also account for most of the degreasing. Table 12 summarizes the results of the survey and the total nonreported emissions. The distribution of emissions from reporting sources, Table 13, is also useful for descriptive and planning purposes.

The non-reported emissions based on a 100 percent coverage in each SIC of the selected companies is calculated as follows:

$$\text{Non-Reported Emissions} = \frac{\text{(Reported Emissions)}}{\text{coverage fraction}} - \text{(Reported Emissions)}$$

$$E_{N-R} = E_{R/C} - E_R$$

This assumes that emissions are proportional to the total number of employees within the pertinent SIC codes.

Table 11. SAMPLE SHEET FOR THE ANALYSES OF TYPE OF HYDROCARBON EMISSIONS FOR STANDARD INDUSTRIAL CODES (SIC)

SIC	Type of source	Pollutants						Emissions reported E_r	% employee coverage C	Emissions non-reported E_{N-R}	Additional emission E_A	Total emissions E_T
20	Point (area)											
21	Point (area)											
22	Point (area)											
23	Point (area)											
24	Point (area)											
25	Point (area)											
26	Point (area)											
27	Point (area)											
28	Point (area)											
29	Point (area)											
30	Point (area)											
31	Point (area)											
32	Point (area)											
33	Point (area)											
34	Point (area)											
35	Point (area)											
36	Point (area)											
37	Point (area)											
38	Point (area)											
39	Point (area)											
5153	Point (area)											
7216	Point (area)											
Totals reported	Point (area)											
Estimated Totals	Point area											

Table 12. TYPE OF HYDROCARBON EMISSIONS VERSUS SIC FOR DEGREASING

SIC	Type of source	Pollutants						Emissions reported E_r	% employee coverage C	Emissions non-reported E_{N-R}	Additional emission E_A	Total emissions E_T
		Stoddard	Trichloro-ethane	Perchloro-ethylene	Methylene chloride	Trichloro-ethylene	Other					
20	Point (area)											
21	Point (area)											
22	Point (area)			34		6		40	1.0			40
23	Point (area)						(2)	(2)		(0)	0	(2)
24	Point (area)											
25	Point (area)											
26	Point (area)	1	1				(1)	(1)	.12	(7)	(2)	(10)
27	Point (area)	3			2	3	4	6	.80	(2)	(0)	6 (2)
28	Point (area)	(6)	8 (1)					9	1.0	(0)	(0)	9
29	Point (area)						(2)	8 (9)	.81	(4)	(1)	8 (14)
30	Point (area)	(1)	30	23	74		12	139				
31	Point (area)		3			(1) 22	(1)	(3) 25	.77	(42)	(10)	139 (55)
32	Point (area)		5					5	.15	(142)	(33)	25 (175)
33	Point (area)	208	40 (1)	7		117 (5)	1 (1)	373 (7)	.24	(16)	(4)	5 (20)
34	Point (area)	37 (16)	425 (14)	71 (5)	2 (1)	407 (36)	2	944 (72)	.62	(229)	(88)	373 (324)
35	Point (area)	8 (8)	77 (4)	20	6	51 (4)		162 (16)	.77	(303)	(71)	944 (446)
36	Point (area)	18	106 (6)	44	13	104 (10)	7 (3)	292 (19)	.84	(34)	(8)	162 (58)
37	Point (area)					42		42	1.0	(0)	(0)	292 (19)
38	Point (area)	1	47	4		(3)		52	.79	(11)	(3)	42 (14)
39	Point (area)		62 (9)	138 (9)	48	476 (40)	7 (8)	731 (66)	.37	(94)	32	52 117
5153	Point (area)								.65	(428)	(100)	731 (594)
72I6	Point (area)											
Totals reported	Point (area)	281 (31)	808 (35)	341 (14)	145 (1)	1228 (99)	46 (18)	2828 (198)				
Estimated Totals	Point area	281 (199)	808 (490)	341 (206)	145 (80)	1228 (816)	46 (43)	2828 (198)		– (1292)	– (342)	2828 (1832)

Table 13. SIZE DISTRIBUTION OF HYDROCARBON EMISSIONS FOR DEGREASING

Emission range	No. of companies	Average size of company (employees)	Total emissions	Emissions, tons per year per employee
< 5 tons/year	135	< 150	143	0.02
5-25 tons/year	53	300	538	0.03
25-100 tons/year	9	830	470	0.06
> 100 tons/year	6	2400	1106	0.08
			2257	

For purposes of comparison, emissions should be estimated by other methods. One method is to obtain trichloroethylene and 1,1,1-trichloroethane degreasing solvent usage from "Chemical Profiles"[12] or from the "Chemical Economics Handbook,"[13] and apportion them by any of these three indicators: manufacturing employees within 34 to 39 Codes, total manufacturing employees, or population. The above indicators are given in decreasing order of accuracy. Another method is to obtain total usage estimates from local suppliers who are well informed on marketing. Reasonable judgment should be exercised to determine any increase or decrease in the estimate depending upon coverage and any additional information known about the region. By choosing the higher estimate, the non-reported emissions figure would be conservative. The control strategies would be more stringent, requiring a slightly higher reduction.

If additional emissions are estimated for the region, they can be apportioned to SIC codes by the extent of the coverage and the quantity of reported emissions.

$$E_{A_i} = \frac{E_{Ri/Ci} - E_{R_i}}{\sum_{i=1}^{n} (E_{R/C} - E_R)_i} = \frac{E_{N\text{-}R_i}}{\sum_{i=1}^{n} E_{N\text{-}R_i}}$$

where E_{R_i} = additional emissions for the ith SIC

E_{R_i} = reported emissions for the ith SIC

$E_{N\text{-}R_i}$ = non reported emissions for the ith SIC based on a 100 percent coverage

C = coverage fraction

n = number of SIC categories

The total non-reported and additional estimated emissions are considered as area sources (non-identified point sources and area sources) and are reapportioned to pollutant categories by reported emissions. The total regional area source emissions will become the degreasing

portion of the NEDS area source county entries "Solvent Purchased." This regional total is apportioned to counties by (1) non-responding 34 to 39 SIC manufacturing employees, (2) manufacturing employees in SIC 34 to 39, or (3) all manufacturing employees. The indicator is chosen in decreasing order depending on availability of census data.

Dry Cleaning - The emissions from this industry are due to two types of solvents; petroleum or Stoddard solvent and perchloroethylene. Perchloroethylene is used in much larger quantities than Stoddard, and about 80 percent of the perchloroethylene produced annually is used by dry cleaners. The remaining 20 percent is used for chemical intermediates and degreasing. All solvent purchased by dry cleaners is assumed to be evaporated.

Total estimated emissions from the survey are calculated based on 100 percent establishment coverage for the one SIC 7216. Three other methods are available for comparing perchloroethylene usage. The first method is based on dollar receipts spent on dry cleaning from the Census of Business.[14] The amount is calculated using conversion factors from the International Fabricare Institute.[15] In 1970, $1.50 was spent per 3.5 pounds of clothes cleaned and an average of 6.9 gallons of perchloroethylene is used to clean 1,000 pounds of clothes. The second method is based on estimates from major manufacturers and suppliers of dry cleaning solvents. They usually can provide information on regional usage. The third method is based on EPA consumption factors, 2 pounds of solvent evaporated per person per year, or 2.7 pounds per person per year for colder climates.[5]

Solvent usage by each county is determined by using the results of the point sources from the questionnaire and by proportioning the remaining estimated solvent used in this region. Two apportioning methods are available. The first method of proportionment is based upon the number of dry cleaners who did not respond to the questionnaire and an

estimate of the population served by those establishments. The population served by the nonrespondents is determined by multiplying the fraction of dry cleaners that did not respond by the total population of that county. The second method assumes that each nonrespondent uses an equal amount of solvent, and apportions the remaining estimated solvent by the number of nonrespondents per county.

Surface Coating - This section will discuss the hydrocarbon emissions resulting from the application of coatings. This category doesn't include hydrocarbon emission resulting from chemical manufacturing, food and agricultural products manufacturing, petroleum refining, basic wood manufacturing, and textiles refinishing. Surface coating deals exclusively with applying a thin layer of coating on the surface. For purposes of discussion, it has been divided into four categories:

1. Fabric or rubberized coating
2. Protective or decorative coatings such as paints, lacquers, varnishes, etc.
3. Printing inks
4. Miscellaneous coatings such as adhesives and coatings for paper, leather, film and glass

Fabric or rubberized coatings - This section discusses and estimates the hydrocarbon emissions from establishments engaged in manufacturing coated and impregnated textiles, rubberized fabrics and other miscellaneous coated products such as insulating tapes and pipe wrap. The products are tailored from numerous decorative and/or protective polymeric coatings applied to a variety of fibrous, knitted, or nonwoven textile support webs using the following techniques:[16]

- Impregnation or saturation process
- Surface coating process with
  1. "Wet" or solvent-containing coatings
  2. "Dry" or hot melt coatings (casting)
  3. Lamination of preformed film

Although most polymeric compounds can be applied by any one of these methods, certain factors such as uniformity, esthetics, softness and protection enter into the selection of the process.

For example, in polyvinyl fabrics, the base layer is applied either by laminating the film or by casting the hot melt containing 5 percent solvent over a previously laid adhesive. An outer decorative layer, which contains ink, polymer, and about 80 percent solvent, is then coated "wet" by knife-over-roll. Only the saturation and "wet" surface coating processes use significant quantities of solvent which will then be emitted upon drying or curing the coated material.[24] Some of the solvents often used are toluene, naphtha, mineral spirits, and MEK. The classes of coatings often applied are: rubber, cellulose derivatives, polyvinyl, olefinic, polyester, acrylic, and polyurethanes. Sometimes epoxy or silicone adhesives are used to bind the coating to the fabric.[17] The emissions from them are included in this section.

The industries covered by this section are classified by SIC 22 (2231, 2295, 2297) and 30. Total emissions from each SIC category are scaled to 100 percent coverage according to manufacturing employees within each SIC. Since numerous types of coatings and application techniques exist, and any one coating can be used in large quantities in any one area or establishment, a national-to-regional breakdown is impractical. That portion of the total emissions not included in point sources is apportioned as area sources to counties by SIC 22 and 30 manufacturing employees. It is represented in the solvent purchased category.

Protective and decorative coatings (paints) - This section includes the application of paints, lacquers, varnishes, shellacs, primers, and enamels for protective or decorative purposes. This class of coatings is referred to by the industry as "paints" and are classified into two categories, industrial or trade paints. Industrial paints are products that are formulated and sold to other manufacturers (frequently in

large containers) for factory application. Trade paints are shelf products that are sold through retail stores to the general public, professional painters, and builders. These products are largely architectural coatings for the outside and inside of new and existing structures. Industrial paints that are applied in large quantities at a fixed locations usually become classified as point sources. Non-point sources using industrial paints are accounted for in the "Solvents Purchased" entry of the NEDS area source file. Trade-sale paints are by definition exclusively area sources and are included in the last section. But, because the emissions are estimated by the same method and are also represented in NEDS by the field "Solvent Purchased," they are discussed here.

Paints are applied by brushing, spraying, rolling, flow coating, or dipping. Industrial paints are used in the manufacturing industries, SIC 24 to 39, and automotive repair shops, SIC 75. Automotive repair shops are almost always area sources, although if the methodology as described in previous chapters is followed, some large auto body shops should be contacted. As before, total emissions are estimated from a national-to-regional breakdown because of several factors, including the inavailability of records of the quantities of the many types of paints purchased, and information concerning the percentage of solvent content in the purchased paint and the actual paint applied.

The methodology for estimating total paint solvents emitted from national figures to regional figures involves the use of two reference sources and some assumptions about the density and average solvent content in paints. The "Chemical Economics Handbook"[13] provides national estimates of industrial paint sale volume, solvent based trade sale paint volume, and total solvent usage in paint. From this information it is possible to determine relative solvent emissions from industrial and trade sale paints, if an average weight per gallon and average solvent content could be determined for regional industrial or trade

paints. Unfortunately, definitive information regarding the above is not always available from local industrial manufacturers and suppliers. If we can consider the survey results as representative, then industrial paints average about 9 lb/gal and 67 percent solvent. Using the CEH figure of 400×10^6 gallons of industrial paint, then 1,200,000 tons of solvents were emitted in the United States during 1970 from industrial paint. Since CEH reports that 1,700,000 tons of solvents were used in 1970, then 500,000 tons must have been used in solvent-based trade paints. Solvent content of the 937,000 tons of solvent-base trade paints would average 53 percent which is perhaps somewhat high. Water-based trade paints contain about 3.5 percent volatile hydrocarbons and for 1970 would emit 50,000 tons of hydrocarbons. National emissions can be estimated for a different base year using growth rates also given in the above reference.

Although regional apportioning factors could be based on manufacturing employees for industrial paints and population for trade paints, the National Paint and Coating Association (NPC)[18] publishes a percentage breakdown of industrial and trade paint usage for nine U.S. regions. The last survey accounted for almost one-half of the national sales. The U.S. Census of Transportation also publishes similar figures about every five years. Tables 14 and 15 compare the breakdowns for industrial and trade paints obtained from NPC, 1967 census, and those calculated from regional population and manufacturing employees. Although the methods show good agreement only for some regions, the latest NPC survey or census figures should be applied. They are the only direct measures of regional paint sales.

To obtain state, county, or study area figures, regional figures can then be apportioned by manufacturing employees for industrial paints and by population for trade paints.

Printing - The printing ink industry is another surface coating category that uses solvents. There are five basic types of printing operations:

Table 14. PERCENTAGE BREAKDOWN OF TRADE PAINT SALES FOR U.S. REGIONS

Region	Percent of total		
	1972 NPC trade sales	1967 merchant wholesale	1970 population
New England (Me., N.H., Vt., Mass., R.I., Conn.)	5.7	6.9	5.8
Middle Atlantic (N.Y., N.J., Pa.)	13.2	25.9	18.3
East North Central (Ohio, Ind., Ill., Mich., Wisc.)	21.9	19.9	19.8
West North Central (Minn., Iowa, Mo., Kan., N.D., S.D., Neb.)	10.2	10.7	8.0
South Atlantic (Del., Md., Wash., D.C., Va., W. Va., N.C., S.C., Ga., Fla.)	16.3	15.6	15.0
East South Central (Ky., Tenn., Ala., Miss.)	5.7	2.3	6.3
West South Central (Ark., La., Okla., Texas)	8.2	5.0	7.5
Mountain (Mont., Idaho, Wyo., Colo., N.M., Ariz., Utah, Nevada)	5.8	2.0	4.1
Pacific (Wash., Ore., Calif., Alaska, Hawaii)	13.0	11.8	13.1

Table 15. PERCENTAGE BREAKDOWN OF INDUSTRIAL PAINT SALES FOR U.S. REGIONS

	1972 NPC	1967 Census minus NPC trade (adjusted to 1967)	1967 Manuf. emp.
New England (Me., N.H., Vt., Mass., R.I., Conn.)	3.0	3.7	8.0
Middle Atlantic (N.Y., N.J., Pa.)	10.9	11.9	22.8
East North Central (Ohio, Ind., Ill.)	29.4	31.9	26.8
West North Central (Minn., Iowa, Mo., Kans., N.D., S.D., Neb.)	7.1	10.9	6.2
South Atlantic (Del., Md., D.C., Va., W.Va., N.C., S.C., Ga., Fla.)	19.3	12.7	12.8
East SouthCentral (Ky., Tenn., Ala., Miss.)	8.9	11.0	5.7
West South Central (Ark., La., Okla., Texas)	7.0	14.0	5.6
Mountain (Mont., Idaho, Wyo., Colo., N.M., Ariz., Utah, Nevada)	1.3	1.6	1.6
Pacific (Wash., Ore., Calif., Alaska, Hawaii	13.1	2.2	10.5

letter-press, flexographic, gravure, lithographic, and screen. Whether or not hydrocarbon emissions occur depend on the particular type of ink used for particular methods of application. However, certain types of inks are often used with certain methods. Table 16 indicates the range of percent solvent content in inks for two drying methods versus the five printing processes.[16,19,20]

Table 16. PERCENTAGE OF SOLVENT CONTENT FOR TWO DRYING METHODS VERSUS FIVE PRINTING PROCESSES

Drying method	Letter-press	Flexographic	Litho-graphic	Gravure	Screen
Evaporation	--	Solvent base (40-75%)	--	40-75%	0-60%
Heat set	~10%	Water base (0-30%)	~16%	--	0-60%

The flexographic and gravure process account for approximately one-third of all inks used. They mainly use solvent-based inks containing 40 to 75 percent solvent, which is then evaporated on drying. Water-base inks are also coming into use in the flexographic process. Some of these water-base inks also contain solvent (0 to 30 percent) for faster drying. The screen process uses oil and lacquer-type inks which contain 0 to 60 percent solvents. However, this class accounts for less than 6 percent of the national total solvent used for inks. Letterpress and lithographic inks, which account for about one-third of the total inks used, are oil-based and emit some solvents when heat-set letterpress or heat-set web offset is used. Alcohol type solvents are also used in the water fountain for the lithographic process.

Oil based inks are mostly used in publications of periodicals and books and in commercial printing, whose SIC is 27 (272 and 275). Flexographic and gravure printing, which use mainly solvent-based inks, is mostly used in making miscellaneous converted paper products and paper-board containers, whose SIC is 26 (264 and 265).

Printing hydrocarbon emissions are scaled to a 100% coverage by manufacturing employees. They can be compared to national figures apportioned to the study area. National total solvent used by the printing industry is found in the "American Inkmaker."[21] Applying a 7 percent annual growth rate on the 1967 figures the solvent usage breakdown is given in Table 17.

Table 17. NATIONAL SOLVENT USAGE (TONS/YEAR)

	1967	1973
Oil inks	25,000	37,000
Flexographic/gravure	55,000	83,000
Other	5,000	8,000

The oil-based ink solvent is apportioned by manufacturing employees in SIC 27, and the flexographic/gravure and other solvent is apportioned by manufacturing employees in SIC 26. The results are compared with the survey figures respectively by SIC. Additional regional information about printing is also considered. Any "additional" emissions are redistributed to SIC's and the area source total is apportioned to counties by the indicator used in this section.

Miscellaneous Surface Coatings - This category encompasses the infrequent operations such as the treatment of paper (SIC 26), refinishing of leather (SIC 31), manufacture of magnetic tapes and fluorescent tubes (SIC 36), manufacture of photographic films (SIC 38) and adhesives operations in any other industries not covered above.

Paper is usually "converted" to end products by such treatments as embossing, impregnating, saturating, and lamination. The two classes of coatings used are pigment coatings and barrier coatings. Hydrocarbon emissions occur from the adhesives that bind the pigment, and from the solvent acting as a vehicle in the barrier coatings.

Finishing of leather involves the application of film-forming materials to the grain to provide abrasion and stain resistance and the enhancement of color. Previously leather coatings were restricted to casein, shellac, albumin, wax, and linseed oil. However, today more sophisticated film-forming polymeric substances are used and applied by rotary brush, flow coaters and rotary sprayers. Organic solvents are used as dilutents for the polymeric coatings and are then emitted during the drying stages.[22] The industries that use leather and allied products for the manufacture of shoes and furnishings are also a source of hydrocarbon emissions due to solvents in the adhesives.

If the firms covered by these industries are numerous and not all were surveyed emissions should be scaled by respective SIC manufacturing employees. If, however, it is known that only a few companies are doing these operations hydrocarbon emissions should not be scaled. Some of these rare operations are the manufacture of magnetic tapes, fluorescent tubes and photographic films. The first two involve the application of inorganic particles (iron oxide, fluorescent compound) dispersed in a solvent on to a base (plastic, glass) and the evaporation of the solvent by drying.

Photographic films are coated with polymeric dispersions and solutions which contain solvents. These solvents act as a vehicle to uniformly apply the matrix of layer on to the plastic base film, and are later evaporated and emitted to the atmosphere.

Hydrocarbon Emissions From Manufacturing Not Including Surface Coating and Degreasing - Hydrocarbon emissions from this category occur when the raw or intermediate material, itself, contains hydrocarbons of which some or all may be driven off, or when hydrocarbon compounds are reacted or mixed with the raw or intermediate material. This category can nicely be broken down by SIC industrial classes for discussion purposes. Table 18 gives the type of processes which emit hydrocarbons.

Table 18. PROCESSES EMITTING HYDROCARBON FROM MANUFACTURING

SIC	Description	Processes
20	Food & agricultural products	Fermentation & distillation of alcoholic beverages
22	Textile mill products	Dyeing and finishing
25	Lumber & wood products	Veneer drying
28	Chemicals & allied products	Organic chemical manufacturing Surface coatings manufacturing Specialty chemical manufacturing
29	Petroleum refining and related industries	Petroleum operations except asphalt mixing
30	Rubber and miscellaneous plastic products	Plastic and rubber products operations
31	Leather and leather products	Leather refinishing
32	Mineral products	Asphalt roofing Asphalt mixing
33	Primary metal industries	Coal and coke processing
34-39	Machinery and other consumer products	Fabrication of plastic or resin products: fiberglass boats, toys, etc.

For manufacturing categories, total hydrocarbon emissions should be scaled only when numerous companies are doing the operations described in the above table. National consumption or production of certain products are of little value for regional breakdown, because the companies are likely to be relatively few and unevenly distributed in the United States compared to those doing surface coating, degreasing or dry cleaning. Except for petroleum refining and certain chemical processing operations, the hydrocarbon emissions from these manufacturing operations are relatively small as compared with surface coating.

Bulk Storage of Petroleum and Petrochemical Products - Hydrocarbon emissions from three operations, the filling, storing and emptying of various types of tanks, by the manufacturing industry, oil companies, distributors, utilities and airports are considered here. Most of these three operations are point sources and are coded into NEDS. For example a fixed roof tank might regularly be filled by a marine vessel and emptied by truck. Storage emissions would be both from breathing and working losses. Evaporative area sources are relatively few and are neglected by the NEDS area source form. Gasoline, the only petroleum product emitting significant quantities of hydrocarbons at the retail level, is discussed in a later section on "Exclusively Area Sources Emitting Hydrocarbons."

The data summary tables are different for this category. Table 19 is a good way to represent the data. For each type of operation (or operating variable) the emissions from each type of petroleum product are entered. Emissions are calculated using EPA emission factors.[11]

Emphasis has been placed on obtaining information from all bulk storage sites because they are relatively few in number. This is also important because the emissions can only be recorded as point sources. A check on the questionnaire information can be made by obtaining petroleum transfer at ports published by "Waterborne Statistics."[23] The Army Corps of

Table 19. HYDROCARBON EVAPORATIVE LOSSES AT BULK STORAGE SITES

Operation	Gasoline	Distillate oil	Jet fuel	Kerosene	Diesel	Total emissions by operation
Marine vessel-						
Unloading	858	81	9	3	2	953
Loading	115	8	2	1	1	127
Tank cars/trucks-						
Splash loading	915	75	34	1	--	1025
Submerged loading	1409	88	1	9	10	1517
Unloading	314	--	--	--	--	314
Storage/fixed roof						
Breathing loss	1045	1140	99	71	12	2367
Working loss	807	297	52	25	4	1185
Storage/floating roof						
Standing loss	369	11	0	0	2	382
Storage/variable vapor space						
Working loss	0	0	0	0	0	0
Total emission by product	5832	1700	197	110	31	7870

Engineers records (foreign, coast-wise, internal and local) receipts and shipments of major petroleum products. A flow diagram and material balances for each product can clearly indicate the storage and transport patterns of the region. The sum of the transports at each entry or source place can now be compared. A significant difference would indicate review of the possible storage sites in number and in the accuracy of the information provided.

Exclusively Area Sources Emitting Hydrocarbons

These sources are almost always considered area sources because either they are relatively small emitters and numerous, or they are mobile. This category consists of evaporation from application of trade paints, evaporation from gasoline marketing, combustion of fuels in transportation, non-highway use of motor fuels, and combustion of miscellaneous sources. Area sources from stationary fuel combustion and solid waste disposal have already been mentioned in the beginning of this chapter. The methods for gathering this information is well documented in the "Guide for Compiling a Comprehensive Emissions Inventory," APTD 1135.[5] We will therefore only comment on the first three listed above.

Evaporation From the Application of Trade Paints - The methodology for estimating and apportioning the emissions to counties has already been discussed in the section on Protective and Decorative Coatings--Paints. The emissions from trade paints along with all other process and evaporative hydrocarbon area source emissions are entered in the "solvent purchased" entry in NEDS for each county.

Evaporation From Gasoline Marketing - Gasoline is the only one of the petroleum products, which is emitted in significant ammounts through retail marketing. A diagram of gasoline flow can be completed using the information given in an earlier section on bulk storage and other references found in the methods for estimating county on-highway motor vehicle and off-highway gasoline in "A Guide for Compiling a Comprehensive Emissions

Inventory," APTD-1135.[5] Figure 8 is the flow pattern found in Rhode Island. The NEDS entry on county gasoline marketed is the sum of on-highway and off-highway gasoline use. Calculation methods are also documented in APTD-1135. Evaporative emissions are calculated using an overall emission factor which is the summation of emission factors from five gas station operations. Emission factors are adjusted for an average gasoline vapor pressure. The operations and emission factors at 4.6 psia vapor pressure are given in Table 20.

Table 20. EMISSIONS: LOSSES PER 1000 GALLONS TRANSFERRED

Operation	Pounds
Tank truck unloading	1.6
Storage tank fill (splash)	9.2
Storage tank unloading	0.8
Vehicle fill	8.8
Gasoline spillage	0.6
Total	21.0

Transportation - This is the largest hydrocarbon source and the accuracy of the methodology for estimating the emissions is important. Methods for estimating the emissions are also given in APTD-1135 for all transportation classes, motor vehicles, aircraft, railroads and vessels. Since motor vehicle emissions are by far the largest, the methodology given in "An Interim Report on Motor Vehicle Emission Estimation"[24] should be followed. Although this requires more information gathering and processing, it estimates the emissions more accurately.

Miscellaneous Hydrocarbon Area Sources - Hydrocarbon emissions from these sources are relatively small to the total for most cases. APTD-1135 describes the methodology for estimating the following:

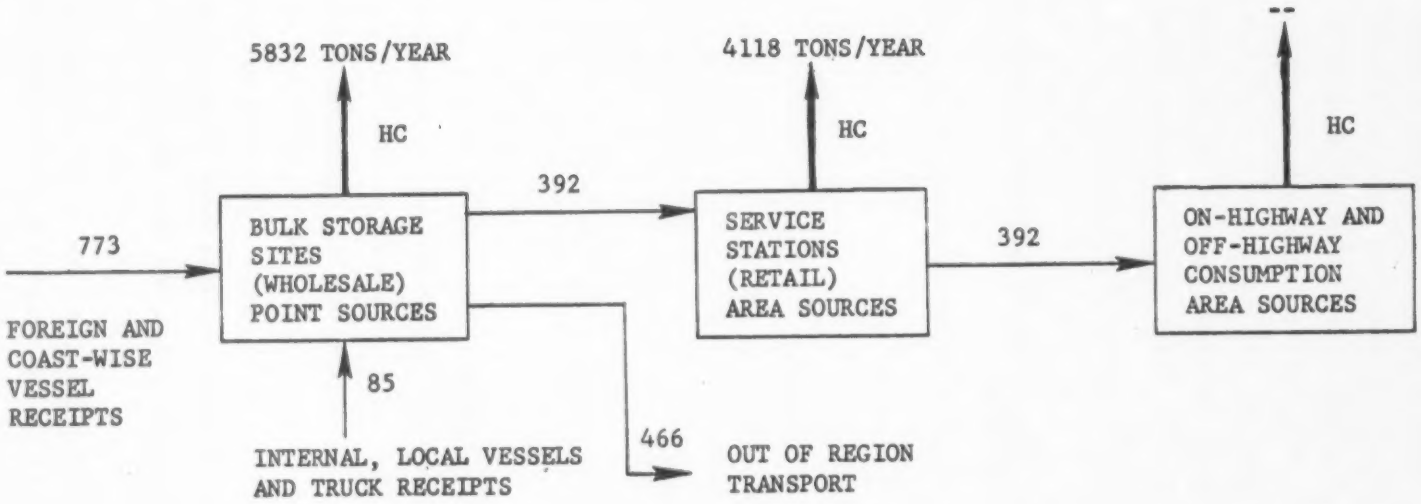


Figure 4. Gasoline flow (10^6, millions of gallons) and resulting hydrocarbon (HC) emissions for the State of Rhode Island.

- Non-highway use of motor fuels
- Acres and quantity of wood burned by forest fires
- Acres and quantity of material burned by slash and agriculture fires
- Structural fires
- Number and size of active coal refuse piles.

EPA emission factors are applied for calculating hydrocarbon emissions.

COMPUTER DATA HANDLING SYSTEM

The development of a computer data handling system involves coding the information onto standard forms and programming the storage/retrieval, processing and report generating functions. The present National Emission Data System (NEDS) has been extensively developed to include and accommodate these functions. It remains to modify and add any deficiencies in coding hydrocarbon point and area source information, and to write the program(s) necessary to generate the tabular summaries found in the "Manual Approach." In this report, only the methodology for generating the summaries is described. The computer programs are not provided.

Survey Coverage and Emission Summary Table

The establishment identification card described earlier for labels, and a response card can be coded for entry into the computer.

The identification card contains the following information:

- plant identification number
- county, AQCR, city codes
- SIC
- name and address

The additional information required to complete the summary table would be on the response card:

- type of source (P, A, N, O, ß)
  P = Point source; A = Area source; N = Not a source;
  O = Out of business; ß = blank, non-respondent
- number of manufacturing employees
- emissions (tons/year) by major category
- Q, T; Questionnaire, Telephone information.

The response card can be completed as the questionnaires or telephone information is received. In addition, the identification information should be verified.

Then a single computer program could read, process and summarize the data in various formats:

- SIC versus coverage by number of establishments, manufacturing employees, source type, and emissions
- Emissions by SIC for each major category
- Listing of non-respondents for enforcement
- Listing of telephone respondents for further verification
- Listing of point sources by city, county, AQCR, SIC, size, etc.

The above summaries can then be used to estimate total hydrocarbon emissions and to compare them with estimated study area figures broken down from national figures by some indicator. Any additional emission estimates would be coded into the area source form. All other area sources emitting hydrocarbons would also be reviewed.

Coding of NEDS Point Source Form

Point source information is coded on NEDS and made available to the many federal and private agencies either in computer readable form or in

printout listings and summaries. Coding instructions are found in the "Guide for Compiling a Comprehensive Emission Inventory" - APTD 1135 [5] and will not be repeated here.

The information concerning hydrocarbon species is not adequately being handled by NEDS to generate the summaries described in the "Manual Approach," or needed for the proper evaluation of the regulations. Four major categories, dry cleaning (SCC: 401001), degreasing (SCC: 401002), petroleum product storage (SCC: 403) and petroleum marketing-transportation (SCC: 406) have an adequate number of SCC's to calculate the type and quantity of hydrocarbon emitted. Other categories, such as the sub-categories in surface coating (SCC: 402) (fabric coating, protective or decorative coatings - paints, printing (SCC: 405), miscellaneous coatings for glass, paper, leather, etc.), food/agricultural industries, chemical manufacturing industries (SCC: 301), wood products (SCC: 307), petroleum industry (SCC: 306), leather products (SCC: 320) and textile manufacturing (SCC: 330) do not have adequate SCC's to describe the process and type of material used.

Generation of Emission Tabular Summaries

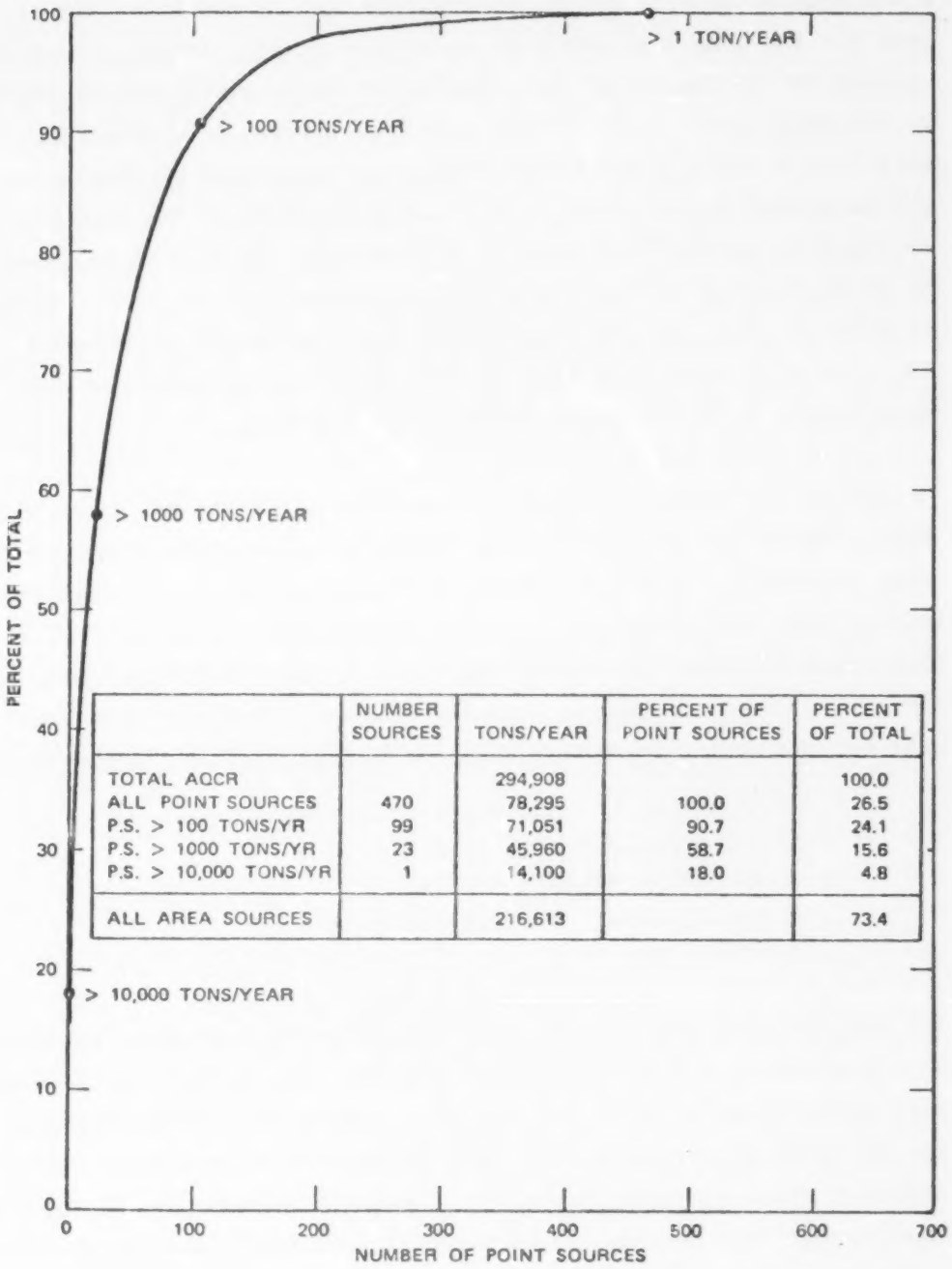
Once the point source information is loaded into the NEDS data files, the hydrocarbon emission tabular summaries described in the "Manual Aproach" of Section V can be produced with a computer program. This could be performed by NEDB or outside by the agency performing the study. As indicated earlier, the SCC codes along with other information in the files would be retrieved for classification. It is expected that the classification will assist in the evaluation of control strategies to meet the oxidant air quality standard.

CHAPTER VI

APPLICATION OF THE HYDROCARBON METHODOLOGY TO THE REGIONAL AIR POLLUTION STUDY

The methodology for inventorying hydrocarbons is a detailed plan to acquire a very extensive data bank. The data will be in much greater detail as to the character of emissions than has been achieved before on a regional scale.[25] In the St. Louis Regional Air Pollution Study (RAPS), the data is needed for the development and validation of mathematical simulation models of air pollution processes. The models are formulations of all of the atmospheric processes such as convective transport, diffusion, physical and chemical transformation, and removal of pollutants. Two models that deal with hydrocarbons are presented in "Urban Air Shed Photochemical Simulation Model Study"[26] and in "User's Guide to Diffusion/Kinetics (DIFKIN) Code."[27] The number of pollutants considered by the models are relatively few, but can be increased as more information is known. For example, more rate constants and stoichiometric coefficients are being estimated for hydrocarbon reactions. Time is an important variable allowing consideration for specific short time intervals.

Several emission inventories have been conducted in the St. Louis area. The NEDS inventory is the last and most recent inventory. The data was originally transferred from the other inventories in the summer of 1973, and will be updated quarterly by the state agencies. It is evident that NEDS is increasing the degree of sophistication and usefulness for planning purposes. A recent analysis of the hydrocarbon emissions inventory for the St. Louis AQCR is shown in Figure 9.[28]



	NUMBER SOURCES	TONS/YEAR	PERCENT OF POINT SOURCES	PERCENT OF TOTAL
TOTAL AQCR		294,908		100.0
ALL POINT SOURCES	470	78,295	100.0	26.5
P.S. > 100 TONS/YR	99	71,051	90.7	24.1
P.S. > 1000 TONS/YR	23	45,960	58.7	15.6
P.S. > 10,000 TONS/YR	1	14,100	18.0	4.8
ALL AREA SOURCES		216,613		73.4

Figure 9. Hydrocarbon emissions for the Saint Louis Air Quality Control Region.[28]

Point sources account for 78,295 tons/year of the total 294,908 tons/year for the AQCR. In addition, only approximately 100 point sources account for 90 percent of the total point source emissions. A total of 470 point sources were coded. Previous studies of hydrocarbon emissions in other areas do not indicate an extensive cataloging of the amount and type of hydrocarbon species. Also, as the effort is increased to obtain more accurate data and more point sources, there is an increase in the percent of the emissions that can be attributed to point sources and monitored for control. Referring to Figure 9, the curve would shift down and to the right, and the points on the curve (e.g., > 100 tons/year) would also shift down.

In summary, the application of this methodology to the St. Louis RAPS program would not only catalog the hydrocarbon emissions by amount and type, but would increase the accuracy of the inventory, describe the emissions by source category and give the emission rates over specific short time periods. To achieve these goals, there are three areas of the methodology discussed in previous Chapters that need more development for the RAPS program than required by most regions. These are:

- Inclusion of smaller point sources
- Delineation of hydrocarbon species for point and area sources
- Determination of hourly emission estimates.

The methodology allows for the inclusion of point sources to any degree of refinement necessary by the RAPS program. The smallest point source that can be coded in NEDS is 1 ton/year. There are several criteria for selecting the emission size that distinguish between point and area sources. Since it takes more time to maintain information on point sources than area sources, the availability of funds is a factor. Another factor would be the percent of emissions required to be monitored by the program. Once again, the economics and the degree of accuracy

are important. It ordinarily follows that the higher the percent of emissions monitored the more accurate the inventory becomes. The precision of the inventory is important for the validation of the simulation models. Another factor to be considered for classifying a point source is whether it can be controlled by the existing or proposed regulations.

Previous chapters have already mentioned that the development of new Standard Classification Codes (SCC) for NEDS will be the partial solution for defining the process and the type of hydrocarbon species being emitted. The SCC file has been designed to include new codes as they are being developed. As they are developed, the general codes which end in 99 can be shifted to these newly defined ones. The photochemical reactivity of these hydrocarbon species can then be considered in the simulation models and the models can then estimate the formation of photochemical oxidants based on the quantity of reactants, reaction rates and amount of energy from sunlight. It should be noted that the methodology discussed in Chapter V already provides for point and area source classification by pollutant, an example of which has been presented in Table 11. Similar tables can be provided for all major categories of hydrocarbon sources and utilized in RAPS programs.

The third area is the development of techniques by which the inventory can be used to estimate emissions over specific short time periods. These techniques should be used when processing or summarizing the information in the data bank. Estimating emissions down to the hourly level, or defining the daily and weekly emission cycle will support the short time simulation modeling efforts. This is very important because the formation of photochemical oxidants occurs during sunlight hours, and is dependent upon the concentration of hydrocarbons during this time. The basis for the NEDS inventory is one year, however, the point source quarterly percent thruput and the number of normal operating hours are recorded for further breakdown of emissions. It is apparent that some of the hydrocarbon emissions are dependent on

the working hours at the establishment. For example, a typical commercial dry cleaner starts work around 7:00 to 8:00 a.m. and operates for 8 to 10 hours. On the surface, the program which estimates hourly emission rates should have hydrocarbons emitted only for the operating hours beginning on the seventh to eighth hour of the day. On the other hand, hydrocarbon emissions from a fixed roof tank occur throughout the day and are dependent on several factors such as temperature, absorption of sunlight, and displacement of the liquid level through transfer operations.

In any event, it is apparent that the NEDS form and the methodology discussed previously here (see page 1 of the questionnaire in Table A-1) do not directly address the question of the daily period of operation and/or emissions. It can be inferred in most instances that sources specifying an 8-hour operation do so over a normal 8:00 a.m. to 5:00 p.m. period. However, to cite the previous examples, a dry cleaning operation may report an 8 to 10 hour operation yet perform much of its cleaning after the closing of its doors to commercial operation. Similarly, in the case of gasoline storage and distribution operations, much of the emissions due to transfer activity may take place throughout the evening.

Most other categories, however, will emit hydrocarbons which will be proportional to the number of operating hours as reported. Most larger emitters will operate and emit on a continuous basis. This will be true for most surface coating operations, power generating plants, large-scale degreasing, printing plants, etc. However, other manufacturing operations may be categorized as cyclic or batch type. These could include many small manufacturing operations and certain process operations, such as batch type coating formulation, plastic and adhesive manufacture, Kraft pulp digestion, blowdown operations at refineries, etc. Their cycles may occur at regular intervals or possibly exhibit hourly, daily, or long term variations due to product demands.

Obviously, when cyclic operations are random or irregular in occurrence, the situation is complex. The importance of such variations, however, may not be serious in that they may be small compared to the overall contributions of temporally definable sources. Nevertheless, the question should be addressed. From the standpoint of the methodology, some modification of the questionnaire should be considered. This would involve the supplementation of existing NEDS information concerning season and normal operating schedules with hourly information. The respondent could be requested to estimate the fraction of sources emitted hourly or at specified intervals of the day: 12 to 6 a.m.; 6 a.m. to 12 p.m.; etc. This estimation could follow a notation as to whether emissions are continuous, cyclic, or irregular, as below:

Emission Cycle:

Continuous ____ Batch ____ Irregular ____

Approximate Percentage of Emissions Occurring During the Day

12 a.m.-6 a.m.	6 a.m.-12 p.m.	12 p.m.-6 p.m.	6 p.m.-12 a.m.

This information should be included preferably throughout the questionnaire to satisfactorily cover plants engaged in multiple operations. Although this methodology is cumbersome and may prove to be an over-refinement of the methodology depicted in Chapter V, it appears to be the only way of determining hourly emission variations.

The problem of diurnal variations of emissions from storage operations can be treated mathematically based on temperature vapor

pressure considerations in much the same manner as seasonal variations. To determine distribution losses due to transfer operations, however, again some assessment of hourly activity must be made. This information could be requested on the questionnaire supplied to the principal gasoline distributors.

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APPENDIX A

QUESTIONNAIRE

Table A-1. QUESTIONNAIRE TO MANUFACTURING INDUSTRIES AND DRY CLEANERS

official use
Rec. by_____Date:_____
SIC_____
X,Y_____

I. GENERAL INFORMATION

A. Company Name_____
Plant Address_____City_____Zip Code_____
Nearest Street Intersection_____
Mailing Address_____City_____Zip Code_____

B. Person to contact about form_____
Telephone_____Title_____

C. Approximate number of employees_____

D. Nature of Business_____
_____

E. Normal Operating schedule
_____Hrs./day_____days/wk._____wks/yr.

F. Approximate Percent Seasonal Operation:

Dec.-Feb.	Mar-May	Jun-Aug	Sept.-Nov.

G. Are volatile organic or solvent-containing materials such as cleaning fluids, coatings, adhesives, inks, etc. used in your operation? ____ Yes ____No

If NO, sign form and return

If YES, sign form and complete only the sections pertaining to your operation:

	Page
II. Dry Cleaning	2, 9 & 10
III. Degreasing	3, 9 & 10
IV. Surface Coating Applications	
A. Fabric and Rubberized	4, 9 & 10
B. Protective or Decorative other than IV-A	5, 9 & 10
C. Printing	6, 9 & 10
D. Miscellaneous Surface Coatings (Adhesives, Paper, Leather, films, Glass etc)	7, 9 & 10
V. Manufacturing Industries	8, 9 & 10

Signature _____ Date _____

II. DRY CLEANING

A. Amount of clothes cleaned per year _____tons.

B. Type of dry cleaning unit ☐ hot or dry-to-dry
☐ cold or transfer

C. Type and amount of solvent cleaner purchased in 1973.

Perchloroethylene_____Gal./Yr.
Stoddard solvent _____Gal./Yr.
Other (specify) _____Gal./Yr.
Other (specify) _____Gal./Yr.

D. Supplier of solvent - Name and address

Perchlorethylene _____
_____
Stoddard Solvent _____
_____
Other (specify) _____
_____
Other (specify) _____
_____

E. Please complete Section VI, page 9.

If you have any questions about this section please contact:

Mr. Roger Schilling
Field Representative for
International Fabricare Institute
5 Shawsheen Ave.
Bedford, Mass.
(617) 275-7583

III. DEGREASING OPERATIONS

A. Type of degreasing: ☐ cold solvent cleaning
☐ vapor degreasing

B. Type and amount of solvent purchased for degreasing operations.

1) Stoddard _____ Gal./yr.
2) 1,1,1-Trichloroethane (Chlorothene VG) _____ Gal./yr.
3) Perchloroethylene _____ Gal./yr.
4) Methylene chloride _____ Gal./yr.
5) Trichloroethylene _____ Gal./yr.
6) Other (specify) _____ Gal./yr.
7) Other (specify) _____ Gal./yr.

C. Suppliers of Solvents

_____
_____
_____
_____
_____
_____

D. Waste solvent disposal method

_____

E. Amount of each solvent returned for reprocessing to vendor or collector

1) Stoddard _____ Gal./yr.
2) Trichloroethane _____ Gal./yr.
3) Perchloroethylene _____ Gal./yr.
4) Methylene chloride _____ Gal./yr.
5) Trichloroethylene _____ Gal./yr.
6) Other (specify) _____ Gal./yr.
7) Other (specify) _____ Gal./yr.

F. Please complete Section VI, page 9.

IV-A. FABRIC OR RUBBERIZED COATING APPLICATION

(1) Material(s) being coated _____.

(2) Type of coating process:

Source No.*	State Coating Process: Impregnation, "Wet" Coating, Hot Melt Coating, Lamination	Type of Coating**	Amount of Coating (Gal/Yr)	Type† and % of Vehicle Solvent		Type† and Amount of Solvent Added to Coating (Gal/Yr)	

(3) Type† of cleaning solvent _____, Amount _____ (Gal/Yr)

_____, Amount _____ (Gal/Yr)

(4) Is any solvent returned to supplier or collector?

_____No _____Yes Type† _____, Amount _____ (Gal/Yr)

(5) Please complete Section VI, p. 9; use same Source No.

*A source is an individual or similar pieces of equipment such as coaters, dryers, etc. It should correspond to the Source No. on page 9. If applicable, it should also correspond to previously reported sources in "Air Pollution Emissions Report" (Form 158-R75)

**Polyvinyl chloride, polyurethanes, etc.

†Toluene, naphtha, mineral spirits, MEK, xylene, chlorinated hydrocarbon, other (specify).

IV-B. PROTECTIVE OR DECORATIVE COATINGS OTHER THAN FABRIC COATING

1. Indicate material being coated _____

_____

2. Type and amount of coating used:

Source* Number	State Application Method: Spraying, Dipping, Roller, Flow, etc.	Type of Paint**	Amount Gals./yr.	% solids	Type† and % of major solvents	

3. Type* and amount of thinner used for dilution and cleaning not included above _____, Amount_____Gal./yr.

_____, Amount_____Gal./yr.

4. Please complete Section VI, page 9.

*A source is an individual or similar pieces of equipment such as spray booths, tanks, dryers, etc. It should correspond to the Source No. on page 9. If applicable, it should also correspond to previously reported sources in "Air Pollution Emissions report" (Form 158-R75)

**(1) paint, (3) varnish/shellac, (4) lacquer, (5) enamel, (6) primer

†If known, - acetone, isopropyl alcohol, MEK, butyl acetate, cellusolve, toluene, etc.

IV-C. PRINTING

(1) Material being coated _____

(2) Type of printing process:

Source No.*	State Printing Process: Letterpress, Flexographic, Lithographic, Gravure, Screen	Type of Ink**	Amount (lb/yr)	Type$ and % of major solvents in ink	

(3) Type$ and amount of solvent used for dilution and cleaning not included above: _____ Amount_____Gal./yr.

_____ Amount_____Gal./yr.

(4) Please complete Section VI p. 9 ; ; use same Source No.

*A source is an individual or similar printing machines, dryers, etc. It should correspond to the Source No. on page 9. If applicable, it should also correspond to previously reported sources in "Air Pollution Emissions Report" (Form 158-R75).

**Solvent based, oil based, lacquer-type, etc.

$Isopropyl alcohol, Ethanol, Propanol, Naphtha/Mineral Spirits, Toluene, MEK, other (specify)

IV-D. MISCELLANEOUS SURFACE COATING APPLICATION
(Adhesives, Paper, Leather, Films, Glass, etc)

(1) Material(s) being coated _____

(2) Type of coating process:

Source No.*	State Coating Process: Spray, Flow, Dip, Roller, Brush, etc.	Type of Coating**	Amount of Coating (Gal/Yr)	Type$ and % of Major Solvents in Coating	

(3) Type$ and additional amount of solvent used for dilution and cleaning not included above _____, Amount _____ Gal/Yr.
_____, Amount _____ Gal/Yr.

(4) Please complete Section VI, page 9 ; Use the same Source No.

*A source number is an individual or similar pieces of equipment using surface coatings. It should correspond to the Source No. on page 9. If applicable, it should also correspond to previously reported sources in "Air Pollution Emissions Report" (Form 158-R75).

**Adhesive type, pigment coating, barrier coating, polymeric coating, inorganic coating, etc. (specify).

$Branched alcohol, linear alcohol, ethyl acetate, toluene, xylene, ethers, MEK, naphtha, other (specify).

V. MANUFACTURING INDUSTRIES

1) Brief Description of Process _____

Source No.*	Process or operation using organic materials**	Type of material processed †	Annual thruput at source	Type †† and % of solvent in material		Quantity of volatile solvent lost to atmosphere during process lbs/yr.	Method used to determine emissions (guess or material balance)

2) Please complete Section VI, page 9 ; use same Source No.

*A source is an individual or similar pieces of equipment processing organic materials. It should correspond to the Source No. on page 9. If applicable, it should also correspond to previously reported sources in "Air Pollution Emissions Report" (Form 158-R75).

**Dryer, reactor, mixing tank, etc.

†Paint, varnish, shellac, lacquer, enamel, primer, adhesive, ink, other (specify).

††Acetone, MEK, butyl acetate, cellosolve, ethanol, naphtha, toluene, mineral spirits, other (specify).

VI. CONTROL AND STACK INFORMATION

Instructions:

(1) A number should be assigned to each piece of equipment that emits hydrocarbons or to a number of similar units that are vented to a common stack. The Source No. below should correspond to the sections previously filled out. If similar equipment have different control equipment please split the source number to a, b or c.

(2) Identify the process or operation from which hydrocarbons are emitted. For example, dry cleaner, degreasing tank, spray booth, reactor, etc. If more than one unit is emitting to a common stack, specify the number of units.

(3) Identify the hydrocarbon control method used such as after-burners, scrubbers, carbon adsorption, condensers, etc.

(4) Indicate approximate efficiency if known.

(5) Indicate installation date of control equipment.

(6) If hydrocarbons are emitted from a stack, provide height, diameter, temperature, velocity and flow rate information in appropriate columns.

	(1)	(2)	(3)	(4)	(5)	(6)				
						Stack Data				
	Source No.	Process or Operation	Hydrocarbon Control Equipment	Efficiency of Control Equipment	Date of Installation	Height (ft)	Inside Dia. (ft)	Temp. (^{o}F)	Velocity (feet per sec)	Flow rate (ft^3/min)
EXAMPLE	99	Paint Mixing Tank	Adsorber	80%	1969	20	1.5	77	20	2100

(7) PLEASE complete the last sections on page 10.

VII. BULK SOLVENT STORAGE

A. Please complete the following information for each storage tank greater than 250 gallons capacity.

Tank No.	Solvent Type	Capacity	Annual Thruput	Type of Fill and Control Equipment *

VIII. EFFECTS OF ENERGY CRISIS

Please state the changes in type and estimated annual consumption of solvent as a result of the energy crisis.

* Submerged fill, splash fill, return vent line, adsorber

Table A-2. STUDY AREA BULK STORAGE INFORMATION

1. Company name: _____

2. Tank location: (name a few nearby cross streets to aid us in locating your facilities on our maps) _____

_____

3. Person completing form: _____ Title: _____

4. Phone number: _____

5. Type of products stored: _____

_____

6. Specify number of fixed-roof tanks at this facility: _____

7. Specify number of floating-roof tanks at this facility: _____

8. Please use the following space to include any information that would aid us in obtaining accurate emission estimates: _____

_____

_____

_____

_____

_____

_____

Table A-2 (continued). STUDY AREA BULK STORAGE INFORMATION

1. Tank location (if available a diagram of area should be supplied.) _____
   _____
2. Tank Identification (number or name) _____
3. Tank capacity, gals. _____
4. Tank dimensions, ft.
   a) Diameter _____ b) Height _____ c) Length _____ d) Width _____
5. Tank shape. Cyclindrical ____ Spherical ____ Other describe _____
6. Tank material of construction. Steel ___ Fiberglass ___ Other describe _____
7. Paint on tank roof.
   a) White ____ b) Aluminum ____ c) Light Grey ____ d) Medium Grey ____
   e) Other describe _____
8. Paint on shell
   a) White ____ b) Aluminum ____ c) Light Grey ____ d) Medium Grey ____
   e) Other describe _____
9. Tank condition. Good ____ Fair ____ Poor ____
10. Average vapor space height, ft. _____
11. Type of tank (check all applicable).
    a) Fixed Roof ____ b) Floating Roof ____ c) Variable Vapor Space (indicate expansion capacity) _____ d) Pressure ____ e) Underground ____
    f) Aboveground ____
12. If tank is floating roof.
    Type of roof: Double Deck ____ Pontoon ____ Other describe _____
    Type of seal: Single ____ Double ____ Other describe _____
    Type of construction: Riveted ____ Welded ____ Other describe _____
13. Chemical name of liquid being stored. _____
14. True vapor pressure of liquid _____ psia at _____ ^{o}F.
15. Density of liquid at storage temperature (lbs per gal) _____
16. Average molecular weight of liquid (lbs per mole) _____
17. Throughput for the year 1973 _____(gals per year)
18. On a seperate sheet please describe any future anticipated storage tanks.
19. Type of loading: vessel___, barge___, truck___(check)
20. Type of filling: submerged___, splash___

Name:_____ Date:_____

Title: _____ Phone: _____

APPENDIX B

LABEL AND WORK SHEET COMPUTER PROGRAM

```
LEVEL  21                    MAIN                DATE = 74109          14/47/04

      DIMENSION  A(45),C(4,26),ZIP(5),SIC(4),PLT(4),NCT(52)
      REAL NAME(54,15)
      DATA CC,BB/'.',' '/
C     READS CITIES
      DO 211 J=1,54
211   READ(5,101)    NCT(J),  (NAME(J,I),I=1,15)
 101  FORMAT(I4,2X,15A1)
      WRITE(6,650)
 299  JCOUNT=1
 300  DO 210 J=1,4
      DO 210 K=1,26
 210  C(J,K)= BB
C     READS SOURCE CARD
      READ(5,100,END=330)PLT,ICT,SIC,A, ZIP
C     SIC + PLT ID TO MATRIX
      DO 212 K=1,4
      C(1,K) = SIC(K)
 212  C(1,22+K) = PLT(K)
      J=2
      K=1
C     NAME + STREET TO MATRIX
      DO 200  I=1,45
      IF(A(I).EQ.CC) GO TO 39
      IF(K.LT.21) C(J,K) = A(I)
      K=K+1
      GO TO 200
 39   C(J,K) = CC
      J=J+1
      IF(J.EQ.4) GO TO 215
      K=1
 200  CONTINUE
C     CITY + ZIP TO MATRIX
C     CHECKS LIST FOR CITY
 215  DO 216 I=1,54
      IF(ICT.EQ.NCT(I)) GOTO 220
 216  CONTINUE
 220  DO 221 K=1,15
      IF(K.GT.10) C(4,K+11) = ZIP(K-10)
 221  C(4,K)=NAME(I,K)
      WRITE(6,550) ((C(L,M), M=1,26), L=1,3),(C(4,M),M=1,15),(C(4,M),
     * M=22,26)
 550  FORMAT(/// 1X,36(1H-),5('+',10(1H-)),'+',25(1H-)/3X,26A1,8X,6('+',
     *10X) /3X,26A1,8X,6('+',10X) /3X,26A1,8X,6('+',10X) /3X,15A1,6H R.I
     *. ,5A1,8X,6('+',10X))
      WRITE(1,250) ((( C(L,M),M=1,26),L=1,3),(C(4,M),M=1,15),(C(4,M),M=
     *22,26),MI=1,2)
 250  FORMAT ( //3X,26A1/3X,26A1/3X,26A1/3X,15A1,6H R.I. ,5A1)
      JCOUNT= JCOUNT + 1
      IF (JCOUNT.LE.7) GO TO 300
      WRITE(6,650)
 650  FORMAT('1',36X,' TEL NO ',3X,' DATE Q IN ',3(1X,' TEL CONT '),3X,
     *'COMMENTS' )
      GO TO 299
 330  STOP
 100  FORMAT(5X,4A1,1X,I4,1X,4A1,45A1,5A1)
      STOP
      END
```